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PORT BYRON AND OTHER SILURIAN CEPHALOPODS

AUG. F. FOERSTE

Received March 4, 1930; published April 30, 1930

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New genera from Port Byron

INTRODUCTION

The Racine fauna is typically developed in the area extending from Milwaukee, Wisconsin, to Chicago, Illinois. A typical Racine fauna occurs in the Cedarville dolomite of southwestern Ohio. Racine relationships appear to occur also in other areas, but usually are confined to few species, the diagnostic value of which for stratigraphic purposes remains to be determined.

The Guelph fauna is typically developed in southern Ontario and in western New York. A typical Guelph fauna occurs in northwestern Ohio. The Peebles dolomite of southwestern Ohio also contains a typical Guelph fauna. In southeastern Wisconsin it has been possible to distinguish an upper Niagaran horizon with distinct Guelph affinities from the underlying Racine fauna, though certain species with Guelph affinities make their appearance already in the Racine. It is evident that the Racine and Guelph faunas are closely related, but the Guelph is regarded as representing a later stage of development.

At Port Byron, on the Mississippi river, about 13 miles northeast of Rock Island, Illinois, an abundant fauna has been obtained containing about 75 species of cephalopods. An aspect similar to that of the Racine is produced by the presence of such genera as *Cyrtorizoceras, Amphicyrtoceras, Phragmoceras, Hexameroceras,* and *Pentameroceras.* However, these are accompanied

by a remarkable number of genera at present unknown elsewhere in either the Racine or Guelph. These include *Centrorizoceras, Metarizoceras, Clionyssiceras, Savageoceras, Worthenoceras, Ectocyrtoceras, Euryrizoceras, Slocomoceras, Byronoceras, Anomeioceras, Perioidanoceras, Chadwickoceras,* and *Stenogomphoceras.* To this list apparently should be added *Leurotrochoceras,* described from Lyons, Iowa, on the west side of the Mississippi River, opposite Fulton, Illinois. Judging from the literature, a fauna similar to that at Port Byron occurs at LeClaire, Iowa, on the opposite side of the Mississippi river from Port Byron.

It has been customary to correlate the exposures at Port Byron and LeClaire with the Racine. It must be admitted, however, that not a single one of the numerous cephalopods found at Port Byron can be identified definitely with any Racine species, though several are closely allied. Savage[1] has proposed for the Port Byron dolomite a distinct horizon, overlying the Racine. He identifies as Racine various exposures between Fulton and Morrison in northwestern Illinois, none of which are in directly contact with the Port Byron dolomite. On the basis of the contained fauna, however, he correlates the Port Byron dolomite with the upper part of the section at Thornton, south of Chicago, where the section is virtually continuous.

Savage correlates the Port Byron dolomite with the Guelph. Among other characteristic species he cites *Pycnostylus elegans, Pycnostylus guelphensis, Conchidium multicostatum, Trimerella acuminata, Monomorella noveboraceum, Megalomus canadense, Tremanotus alphaeus,* and *Tremanotus chicagoense.*

The writer is not familiar with the stratigraphy of the Niagaran on the western side of the LaSalle anticline in northwestern Illinois, but he has been impressed with the fact that he has never seen a typical Racine cephalopod from any locality within this area in the numerous collections examined. This may be due to failure to collect such specimens as exist in that area, but apparently it means that the Niagaran of this area was deposited in a

[1] Savage, T. E., Silurian rocks of Illinois. Bull. Geol. Soc. America, 37, 513–533 (1926).

basin sufficiently distinct from that of northeastern Illinois and southeastern Wisconsin to result in different facies of its fauna.

The Port Byron dolomite is the only horizon in northwestern Illinois in which cephalopods occur in considerable number and variety. In Iowa, the LeClaire apparently represents the same horizon.

The only Niagaran horizon in Iowa from which a considerable number of cephalopods are known is that of the Hopkinton, in the northeastern part of the state. Those described and figured by A. O. Thomas[2] include species of *Huronia, Huroniella,* and apparently also of *Stokesoceras,* which show a striking resemblance to species known from the Manistique formation[3] of the northern peninsula of Michigan, and thence eastward to Drummond island. A similar cephalopod fauna has been described from Lake Timiskaming,[4] directly north of the eastern extremity of Georgian Bay. The Hopkinton and Manistique are regarded as belonging to a lower horizon than the typical Racine. If equivalent strata exist in southeastern Wisconsin and northeastern Illinois they should be sought within the Waukesha formation. The presence of the species described and figured by Whitfield from Ashford, Wisconsin under the name *Discosorus conoideus*[5] *suggests such a relationship, but the presence of this single species* is not sufficient to warrant such a correlation.

The nearest approach to anything resembling the Hopkinton and Manistique cephalopod faunas, including under the latter also that of the Lake Timiskaming area, is found in the Jupiter and Chicotte formations of Anticosti,[6] in the Gulf of St. Lawrence. These formations are of Clinton age.

Those strata in the northern peninsula of Michigan which

[2] Thomas, A. O., Some unique Niagaran cephalopods. Proc. Iowa Acad. Sci., 22, 292–300, pls. 33, 34 (1915).

[3] Foerste, Aug. F., Silurian cephalopods of northern Michigan. Contrib. Mus. Geol. Univ. Michigan, 2, 19–86, pls. 1–17 (1924).

[4] Foerste, Aug. F., Cephalopoda of Lake Timiskaming area and certain related species. Geol. Surv. Canada, mem. 145, 64–93, pls. 10–16 (1925).

[5] Whitfield, R. P., Geol. Wisconsin, 4, 299, pl. 20, fig. 6 (1882).

[6] Foerste, Aug. F., The cephalopod fauna of Anticosti, Geol. Surv. Canada. mem. 154, 257–321, pls. 27–58 (1928).

occur above the Manistique are correlated by Ehlers[7] with the Racine, but the contained fauna appears to be a meager one, and it has not yet been shown that this fauna contains diagnostic species identical with those of the typical Racine. From the little the writer has seen of these more northern Niagaran formations he is of the opinion that they represent deposition in a distinct basin, and that not only the Burnt Bluff and Manistique, but also the supposed Racine of northern Michigan should bear names distinct from those used for approximately contemporaneous horizons in southeastern Wisconsin. Apparently the Niagaran of northern Wisconsin also belongs to the northern Michigan basin.

The next more northern zone of Niagaran strata is that including Manitoba, that part of Ontario west of James Bay and south of the adjacent part of Hudson Bay, and Southampton island which forms the northern boundary of Hudson Bay. In the area bordering on James and Hudson bays these strata have been divided by Savage and Van Tuyl[8] into the following 4 formations, named in descending order:

Attawapiskat coral reef
Ekwan limestone
Severn limestone
Port Nelson limestone

The presence of *Pentameroceras*[9] and of 5 species of *Phragmoceras* in the Attawapiskat limestone suggests a horizon approximately equivalent to the Racine, but none of the 22 species of cephalopods are identical with those known in the typical Racine. The presence of *Stokesoceras* in the Ekwan limestone suggests an horizon approximating that of the Burnt Bluff formation of northern Michigan, but forms of this type are known also from the Manistique and the evidence is not sufficient to be convincing.

[7] Ehlers, G. M., Niagaran rocks of the northern peninsula of Michigan. Bull. Geol. Soc. America, 32, 129–130 (1921).

[8] Savage, T. E., and Van Tuyl, F. M., Geology and Stratigraphy of the area of Paleozoic rocks in the vicinity of Hudson and James bays. Bull. Geol. Soc. America, 30, 339–378 (1919).

[9] Foerste, Aug. F. and Savage, T. E., Ordovician and Silurian cephalopods of the Hudson Bay area. Jour. Sci. Lab. Denison Univ., 22, 1–107, pls. 1–24 (1927).

The Severn limestone contains *Camarotoechia* (?) *winiskiensis, Pterinea occidentalis, Isochilina grandis latimarginata,* and *Leperditia hisingeri fabulina,* of which the last three occur also directly above *Virgiana decussata* in the vicinity of the Grand Rapids of the lower Saskatchewan, in Manitoba. *Camarotoechia* (?) *winiskiensis, Rhynchospira lowi, Pterinea occidentalis,* and *Leperditia hisingeri fabulina* occur also in the Wabi formation of the Lake Timiskaming area, so that all three horizons are regarded as approximately equivalent. The Port Nelson limestone contains the *Virgiana decussata,* originally described from the Grand Rapids of the Saskatchewan, and placed at the base of the Stonewall formation of Manitoba. Apparently all four of the Niagaran formations discriminated in the area south of Hudson Bay occur also on *Southampton Island,* but the stratigraphy of the latter is still very imperfectly known.

Another line of Silurian outcrops[10] extends from King William Land, northwest of Hudson Bay, across Boothia peninsula, and North Somerset, Cornwallis, North Devon, and southwestern Ellesmereland Islands to northwestern Greenland, north of the Kane Basin. Apparently this indicates a line of deposition along the northwestern border of the Canadian shield, formed by granitic rocks. However, nothing is known at present of the possibility of extended faulting or folding along this line of outcrop.

Lissatrypa phoca has been identified at numerous localities along the line of outcrop just mentioned. This species was described originally from Cape Riley, from strata of Niagaran age. A similar species, described by Holtedahl[11] as *Lissatrypa scheii,* occurs in southwestern Ellesmereland associated with *Cladopora rectilineata* Simpson, *Gypidula (Sieberella) coeymanensis prognostica* Maynard, *Spirifer (Delthyris) vanuxemi prognosticus* Schuchert, and *Rhynchotrema (Stenochisma) deckerense arcticum* Holtedahl. This is a typical Lower Helderbergian fauna at about the same horizon as the Keyser of Maryland and Pennsylvania.

[10] Foerste, Aug. F., The Ordovician and Silurian of American Arctic and Subarctic regions. Jour. Sci. Lab. Denison Univ., 24, 27–79, 2 plates (1929).

[11] Holtedahl, Olaf, On the rock formations of Novaya Zemblya, with notes on the paleozoic stratigraphy of other Arctic lands. Rep. Sci. Results Norwegian Exp. to Novaya Zemblya, no. 22, 1–183, 30 plates (1924). Note especially 126–133.

The writer[12] has tabulated all the species listed by various writers from the line of Niagaran outcrops extending between King William Land and northwestern Greenland as associated with *Lissatrypa phoca*, a total of 74 species, to which 11 more should be added as associated with those included in the preceding list at localities from which *Lissatrypa phoca* is not actually listed. It will be noted at once that in this long list not a single species occurs whose affinities are with the Helderbergian. If any indication of the Cayugan is present, the writer has failed to note this fact. This so-called *Lissatrypa phoca* fauna evidently is of Niagaran age. Evidently several horizons are present. However, every attempt to discriminate horizons on the basis of the literature or by examination of the original material preserved in the British Museum of Natural History has failed.

During his studies at the U. S. National Museum, Dr. Christian Poulsen kindly showed the writer such of the Silurian material as he had brought with him from the area north of the Kane Basin in northwestern Greenland, evidently collected from several distinct horizons. When this material is published it will be the first clew offered as to the stratigraphy of the Niagaran in Arctic regions. All other material published so far has no stratigraphic value. Many of the former identifications are not reliable. Neither the paleontology nor the stratigraphy will serve the purposes of modern geology. It is especially desirable that such localities as Cornwallis, Griffith, and Beechy islands be studied stratigraphically with the same care as that devoted to northwestern Greenland by Lauge Koch and his associates.

Nevertheless, one opinion may be ventured regarding the Niagaran fauna along the line of outcrop between King William Land and northwestern Greenland. Such genera as *Conchidium*, *Gypidula*, and *Euomphalopterus* usually indicate the upper or Lockport half of the Niagaran, as classified in Bassler's "Bibliographic Index of American Ordovician and Silurian Fossils." Moreover, there is no close relationship of the Arctic faunas with the

[12] Foerste, Aug. F., The Ordovician and Silurian of American Arctic and Subarctic regions. Jour. Sci. Lab. Denison Univ., 24, 67, 68 (1929).

Niagaran of the southern part of Canada or with the northern part of the United States. Most of the species are new, and most of the remainder are cosmopolitan. Only 11 cephalopods are listed, among which 6 belong to *Armenoceras*. No phragmoceroid or gomphoceroid is included. *Kionoceras myrice*, and the species doubtfully identified as *Armenoceras rotulatum* and *Armenoceras sphaeroidale* suggest upper Niagaran affinities.

Lauge Koch[13] recently has indicated in a broad way some of the results obtained by Christian Poulsen in his studies of the Silurian material brought back by Lauge Koch from northwestern Greenland. The following new formations are proposed, with the affinities here indicated, the list being given in descending order.

Polaris Harbour formation	Ludlow (doubtful)
Cape Tyson formation	Tarannon-Wenlock
Offley Island formation	Upper Llandovery (Clinton)
Cape Schuchert formation	Upper Llandovery

The supposed Polaris Harbour fossils were collected from an erratic boulder. The Cape Tyson fauna is an Arctic fauna with slight American affinities; the graptolites have English-Scandinavian affinities. The Offley Island fauna is a typical Arctic fauna with many new species, though several have affinities with the American Clinton. The Cape Schuchert fauna is an Arctic fauna, almost all the species being new, though several graptolites, including *Monograptus convolutus*, *Monograptus lobiferus*, *Rastrites peregrinus socialis*, and *Climacograptus scalaris*, have affinities with the Upper Llandovery.

In this connection it is important to emphasize the increasing evidence that the Silurian faunas of the American Arctic have their own characteristic facies. Aside from the graptolites and a few other cosmopolitan forms, they consist of distinct species, and are not mere immigrants from American or European sources. This is true not only of all the Silurian faunas from northwestern

[13] Koch, Lauge, The stratigraphy of Greenland. Jubilaeumsekspeditionen nord om Grønland. Saertryk af Meddelelser om Grønland, 73, no. 2, 1–204 (1929). Note especially pp. 237–242.

Greenland as studied by Poulsen, but also of those described so far from the remainder of the American Arctic Archipelago. Everyone who has studied the Arctic faunas from the areas north of America and Europe must have been impressed with the scarcity of species showing any definite relationships with either of these two continents. Moreover, the poverty of the Silurian faunas from the north of Europe, in other words on the Arctic border of Russia,[14] in the number of species represented, is of some importance. Only the Downtonian is represented in Spitzbergen. If Silurian is exposed anywhere along the eastern border of Greenland, that fact has not yet been sufficiently demonstrated.

It is evident that the Silurian faunas of the American Arctic Archipelago need a complete restudy, based on material freshly collected by persons familiar with methods of stratigraphical research, before the problem of the origin of the Arctic Silurian faunas can be attacked intelligently. What is needed is a series of well-planned American expeditions, similar to those led by Lauge Koch to the eastern and western shores of Greenland.

How far the Silurian faunas of Manitoba and the Hudson Bay areas can be traced northward is unknown at present. In a southward direction they evidently show affinities with those of the northern peninsula of Michigan and of Lake Timiskaming, at least in the presence of *Discosorus*, *Stokesoceras* and *Huroniella*. *Ephippiorthoceras* and *Chicagooceras* also indicate American affinities. *Pentameroceras* and *Phragmoceras* are common to both Europe and America. Apparently these Silurian faunas of the Manitoban and Hudson Bay areas also are indigenous in American Arctic seas, with some immigrants from European sources by way of paths south of the Canadian shield.

The Silurian faunas of northern Michigan and the Lake Timiskaming area find their nearest relationships in the faunas of Manitoba and the Hudson Bay areas. If the Attawapiskat fauna of the Hudson Bay areas is present, it may occur in that part of the northern Michigan section which overlies the Manistique.

[14] Holtedahl, Olaf. On the rock formations of Novaya Zemblya (1924). (See note 11.) Note especially 122–125.

The Racine and Port Byron are the most northern of the continental American Silurian formations, in the areas here under discussion, in which the contained faunas show definite European relationships. In the Racine this relationship is shown especially by the crinoids, cephalopods, and trilobites. Among the Racine cephalopods, European relationship is shown especially by the genera *Ascoceras, Ophidioceras, Cyrtorizoceras, Lechritrochoceras, Phragmoceras, Inversoceras, Mandaloceras, Hexameroceras,* and *Pentameroceras.* The Racine specimens described by the writer under the generic names *Uranoceras* and *Gigantoceras* also appear to have European relationships, but not as close as those mentioned in the preceding list. Among the Port Byron cephalopods, European relationships are shown by the genera *Ascoceras, Cyrtorizoceras, Phragmoceras, Tubiferoceras, Mandaloceras, Hexameroceras,* and *Pentameroceras.* To these should be added *Metarizoceras,* which evidently belongs to the *Rizoceras* group, in the broad conception given to this term by Hyatt in his original description of that genus. The numerous new genera of cephalopods here described, known so far only from the Port Byron, are of special interest, showing special lines of development whose origin at present is unknown.

There are three European areas in which Silurian cephalopods are abundant. These are the Bohemian part of Czechoslovakia, especially that part near Prague; the island of Gotland, southeast of the mainland of Sweden; and England. Of these, the Bohemian cephalopod fauna is well known, through the monumental works of Barrande. Only a few of the Gotlandian genera of cephalopods have been well studied and adequately described, but the collections in the Riksmuseum at Stockholm contain a wealth of material second only to that of the Narodni Museum at Prague. The Silurian cephalopods of Great Britain were ably described by Blake.

Among the Racine cephalopods, those referred to *Uranoceras* and *Gigantoceras* have Bohemian relationships. This is true also of *Metarizoceras,* among the Port Byron cephalopods. All of the remainder, as far as they show any affinities with European forms, could have come as readily from Gotlandian areas as from Bohemian seas.

As a matter of fact, no one has ever made a careful analysis of European and American Silurian faunas, with a view of determining their relative affinities. A large part of these faunas has not yet been studied with sufficient exactness to provide reliable data. This, however, should be one of the goals set for the near future.

It is recognized that most of the fossils found in Silurian strata lived in relatively shallow seas. In that case their migration across waters of abysmal depth could not have been an ordinary occurrence. At present, the shallower depths offering the best paths for migration of shallow water forms extend between Scandinavia and the British Isles westward to Iceland and southern Greenland. Therefore, more numerous affinities might be expected between the faunas of northern Europe and those of northern America. However, there is no reason to believe that present oceanic depths are any indication of conditions in Silurian times. It is known that at present the northern Atlantic is divided into three main zones extending in a north and south direction. Of these, the eastern and western are of much greater depth than the middle zone. But these greater depths may have originated during times of Caledonian and Appalachian periods of folding, and may have been accentuated at later times, leaving us no clue as to conditions during the Silurian.

In a similar manner, we know nothing of the ocean currents in Silurian times. At present, the Gulf stream carries an American fauna from south of Newfoundland toward western Europe, and returns in the form of a much colder current from the more northern parts of Europe to the northeastern coast of America. But the direction of currents during Silurian times is unknown.

As far as the Racine and the closely related Port Byron faunas are concerned, their present distribution and that of the faunas most closely related to them in North America suggests that they migrated along the southern border of the Canadian shield, and that therefore the affinity of these faunas should be closer to that of the Baltic areas than to that of western Bohemia or Czechoslovakia. The presence of *Pentameroceras* and *Phragmoceras* in the Attawapiskat limestone of the area south of Hudson

Bay may be explained more readily by migration westward and northward around the southwestern part of the Canadian shield, than by a southward migration along the Hudson Bay depression; at least in the present state of our knowledge of Arctic Silurian faunas.

ACKNOWLEDGMENTS

In the preparation of this paper the writer has been favored, as heretofore, by the loan of material belonging to different museums and collections. Of these, the collection of Prof. T. E. Savage and that belonging to the U. S. National Museum, under the charge of Dr. R. S. Bassler, are especially rich in cephalopods from the Port Byron area in northwestern Illinois. About a dozen Port Byron cephalopods belong to Walker Museum, at the University of Chicago, in charge of the curator A. W. Slocom. Additional specimens from the same locality and horizon, were borrowed from the Museum of the University of Illinois through the kindness of Prof. T. E. Savage; from the Illinois State Museum of Natural History, of which Dr. A. R. Crook is director; and from the Museum of Comparative Zoology, at Harvard University. Through the support of Prof. Percy E. Raymond, large collections of Silurian cephalopods, chiefly of Racine origin were loaned by the Museum of Comparative Zoology for a period of three years, and formed the basis of study of the cephalopods from this horizon also in other collections. As heretofore, Dr. Chester A. Reeds of the American Museum of Natural History loaned for purposes of comparison the necessary types from the Hall collection. Finally, a few specimens from the Cedarville dolomite at Wilmington, Ohio, were borrowed from the collection of Dr. L. D. Welch, now deposited in Wilmington College. To all of these the writer gratefully acknowledges his indebtedness and appreciation. Most of the studies here recorded were made at the U. S. National Museum under the favorable conditions made possible by the kind consideration of the curator, Dr. Bassler.

Most of all the writer is indebted to Prof. G. H. Chadwick. When the writer began his studies on the Port Byron cephalopods

he found that Prof. Chadwick had already been engaged for a considerable time on the cephalopod material from this locality, at that time in the possession of the Ward establishment at Rochester, New York; later acquired by the U. S. National Museum. With great liberality Prof. Chadwick turned over these specimens and the results of his labors to me, and I can not thank him enough for his kindness.

ASCOCERAS Barrande

Genotype: *Ascoceras bohemicum* Barrande, Systeme Silurien du Centre de la Boheme, pls. 93, 94, 96 (1865).

Conchs known chiefly from elongated gerontic sack-like expansions, including the later stages of the living chamber. These expansions are more or less fusiform in outline, compressed laterally, and narrowed at the top into a more or less cylindrical extension, here called the neck. The septa within the interior of these sack-like expansions are closely crowded and approximately horizontal at the siphuncle and ventrad of the siphuncle, but dorsad of the latter they rise in the form of saddles to successively higher elevations. The lower parts of these saddles usually are closely approximated or are in actual contact with each other, but farther up they become distinctly, and usually widely separated. That part of the conch which preceded the gerontic sack-like expansions evidently was of smaller diameter and probably resembled a moderately curved orthoceroid whose convex outline was ventral. The siphuncle evidently was located ventrad of the center of the conch. Within the gerontic sack-like expansion its segments are nummuloidal in form, but in the earlier parts of the conch their form may have been tubular.

Ascoceras is known only from the Silurian. In the Ordovician its place is taken by *Billingsites*, in which the gerontic sack-like expansions are depressed dorso-ventrally, and in which the necks are shorter. *Probillingsites*,[15] also of Ordovician age, is regarded as ancestral to *Billingsites*.

[15] Foerste, Aug. F., A restudy of American Orthoconic Silurian cephalopods. Jour. Sci. Lab. Denison Univ., 23, 317, pl. 71, figs. 2 A, B (1928).

Ascoceras is most abundant in Bohemia, but occurs also in the Gotland part of Sweden, and in England. In America it is known from the Guelph of southern Ontario, the Huntingdon of northern Indiana, and the Port Byron of northwestern Illinois.

1. **Ascoceras southwelli** Worthen

Plate VIII, fig. 2

Ascoceras southwelli Worthen, Geol. Surv. Illinois, 8, 151, pl. 27, figs. 2, 2a (1890).

Specimen 40 mm. long, including only the living chamber formed last, but not the immediately preceding living chambers which formerly formed the dorsal side of the gerontic enlargement, which usually is all that remains of the conch. At its base there are two very short and nummuloidal segments of the siphuncle, and a trace of a third segment. The radius of curvature of the ventral outline is 30 mm., except at its top, where for a length of 7 or 8 mm. there is a slight reversal of curvature, the upper part of the chamber contracting into a neck. A reconstruction of the former dorsal outline of the gerontic enlargement of the conch suggests that its lower half was gently convex, and its upper half concave. The original maximum dorso-ventral diameter of this part of the conch is estimated at 13 or 14 mm., contracting to 8 mm. at the crest of the last formed dorsal saddle, and to 7.5 mm. at the aperture nearly 9 mm. farther up. The corresponding lateral diameters are 10 mm., 7.5 mm., and 7 mm. The suture of the septum formed last rises strongly in a dorsad direction to a point about 6 mm. above the lowest part of the chamber, then bends abruptly in a ventrad direction, and after a broad reversal of curvature reaches the dorsal outline at a point about 29 mm. above the base. Evidently at least two additional camerae with conspicuous dorsal saddles formerly occupied that part of the dorsal side of the specimen at present presenting a deeply concave outline. This is indicated by the two very low and flat nummuloidal segments of the siphuncle which remain at its base. The uppermost of these is about 3 mm. in diameter, and the one directly beneath is of almost the same diameter. Both segments wedge to a thin edge in a dorsad direction.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 2588, in the Illinois State Museum of Natural History; holotype.

Remarks.—In *Ascoceras indianense* Newell, from the Huntingdon formation of northern Indiana, the ventral outline is distinctly concave at its base, and the greater part of its dorsal outline is faintly concave. The upper part of the neck is more nearly erect, instead of sloping in a dorsad direction.

2. **Ascoceras croneisi** Sp. nov.

Plate XXV, figs. 4 A, B, C; 17 A, B; 18

Compared with *Ascoceras indiananse* Newell, the ventral outline of the gerontic group of living chamber is distinctly convex for a greater part of its length, there being no distinct concave portion along its lower part, nor a slightly concave portion beginning below the level of the uppermost dorsal saddle. The most complete specimen is 25 mm. long. Its convex ventral outline has a radius of curvature of 15 mm. along its lower third, changing to 25 mm. along its upper two-thirds. Its dorsal outline is almost straight, but faintly concave at mid-height. At the base of the specimen its diameter is 6.2 mm., and at its top it is 6 mm., the cross-section being nearly circular at both ends. However, at mid-height its dorso-ventral diameter is 9.8 mm., and its lateral diameter is 7.1 mm., thus showing distinct lateral compression. The suture at the base of the gerontic series of living chambers slopes strongly downward in a ventrad direction, as in other species of this genus. Only the basal part of the neck is preserved. No. 2320-a, Harvard University. Plate XXV, figs. 17 A, B.

A second specimen from the same locality is a cast of the interior of the lower part of the living chamber formed last, and shows the lower part of the last formed dorsal saddle. Beneath it are exposed 4 segments of the siphuncle. Of these, the upper three are low and broad, having a total length of slightly more than 1 mm., while the single segment beneath is as long as the upper three together. The uppermost segment is 3 mm. in diameter; the

third from the top is 2 mm.; and the lowest one of the series is 1.5 mm. The latter is the uppermost segment belonging to the more cylindrical part of the conch, the latter being rarely preserved. No. 2320-b, Harvard University. Plate XXV, figs. 4 A, B, C.

A third specimen from the same locality consists of the gerontic group of living chambers, whose shell is marked by low transverse lines, about 12 or 13 in a length of 5 mm., readily seen only under a lens. These lines slope moderately downward in a ventrad direction. No. 2320-c, Harvard University.

A fourth specimen suggests that the cylindrical neck at the top of the gerontic group of chambers may have been 11 or 12 mm. long, but this is not certain. No. 2320-d, Harvard University.

A fifth specimen presents the sutures of the camerae beneath the cast of the interior of the living chamber formed last. These indicate that at least two additional living chambers occupied the gerontic enlargement of the conch, each of which contained a very short and broad nummuloidal segment of the siphuncle at its base. The underlying camera was distinctly longer then the other two along the ventral outline of the conch, and evidently was occupied by a much longer and less nummuloidal segment of the siphuncle. No. 2322, Harvard University. Plate XXV, fig. 18.

Occurrence.—Wauwatosa, Wisconsin; in the Racine. Also found in the 26th Street quarry, in Milwaukee, Wisconsin. The Wauwatosa specimens here described are numbered 2320a, b, 2322, in the Museum of Comparative Zoology, Harvard University.

Named in honor of Carey G. Croneis.

3. **Ascoceras townsendi** Whiteaves

Ascoceras townsendi Whiteaves, Pal. Foss., Geol. Surv. Canada 3, pt. 1, 41, pl. 6, figs. 4, 4a (1884).

Conch readily distinguished from other American species by the shortness of the gerontic enlargement of the conch, the uppermost saddle being only 16 mm. above the base of the specimen.

Within this short length there are 3 strongly sigmoid dorsal saddles. The cross-section of the conch has been figured by Whiteeaves as having a maximum dorso-ventral diameter of 11 mm. and a lateral one of 7.5 mm. The basal part of the specimen presents a funnel-shaped outline, abruptly rounded at its base, but the upper part of this gerontic enlargement of the conch is missing, and it is not probable that this upper part of the conch failed to contract, as in all other species of this genus, the convexity of the lower part of its ventral outline continuing as far as the point where this gerontic enlargement of the conch contracts into a neck. The passage of the siphuncle through the septum at the base of the specimen is near the ventral side of the conch. It is of small size but nothing is known of the segments of this siphuncle within the camerae.

Occurrence.—Durham, about 27 miles south of Owen Sound, Ontario; in the Guelph dolomite. This is one of the richest localities for Guelph fossils in Ontario, having furnished 67 species, 15 of which were new.

Remarks—In the course of the sutures of the septa along their dorsal saddles this species resembles the specimen incorrectly identified by Blake (British Fossil Cephalopoda, 1, 208, pl. 26, figs. 10, 10a, 10b, (1882)) as *Ascoceras bohemicum*. The ventral outline of this figure is concave. Since this is abnormal for species of *Ascoceras*, the original specimen represented by this figure needs further study. The specimen was described from the Upper Ludlow, of Whitecliff, England, and is preserved in the Museum of Practical Geology, in London.

OPHIDIOCERAS Barrande

Genotype: *Ophidioceras simplex* Barrande, Systeme Silurien du Centre de la Boheme, 2, pt. 1, 184, pl. 97, figs. 1–12 (1867); selected here as the genotype. *Ophidioceras amissus* Barrande, described first, is only imperfectly known.

Conchs coiled, successive volutions merely in contact, except along the upper part of the living chamber, which is free. The median part of the ventral side is distinctly elevated into a narrow, flat or faintly concave zone, which is abruptly bordered laterally

by a moderately concave groove. Margin of the aperture indented by 3 narrow lobes, one ventral and two dorso-lateral, the ventral one being the hyponomic sinus. The dorsal and lateral crests curve inward, narrowing the aperture to a Y-shaped opening. The sutures of the septa have broad lateral lobes. The siphuncle is near the ventral side of the conch but not in contact with the latter. It is small and tubular in form. The cross-section of the conch is laterally compressed in *Ophidioceras rudens* and *O. proximus;* but is dorso-ventrally depressed in *Ophidioceras tener, O. simplex,* and *O. tessellatus.*

In Europe *Ophidioceras* is most abundant in Bohemia, but occurs also in the Gotland part of Sweden and in England. In America it is known in the Cedarville dolomite of Ohio, the Racine of Wisconsin and northeastern Illinois, and the Port Byron of northwestern Illinois.

4. **Ophidioceras wilmingtonense** Foerste

Plate XIV, fig. 7; plate XXV, fig. 6

Ophidioceras wilmingtonense Foerste, Jour. Sci. Lab. Denison Univ. 21, 66, Pl. 24, figs. 3, 4 (1925).

Two specimens were figured in the publication cited above. One of these, the type, was from the Cedarville dolomite at Yellow Springs, Ohio. The other was from the Racine of Wisconsin, probably from Wauwatosa. A third specimen, from the Cedarville dolomite at the Moodie quarry in the southeastern part of Wilmington, Ohio, is there described but not figured. This missing figure is here supplied as fig. 7 on plate XIV. The sutures of the septa of this specimen occur in the grooves between the transverse ribs, and they curve only slightly downward laterally. This specimen belongs to the Austin collection in the U. S. National Museum.

A closely similar specimen occurs at Wauwatosa, Wisconsin, but it enlarges slightly more rapidly in a dorso-ventral direction. This specimen consists of three and one eighth volutions. The umbilical opening has the outline of a broad and short comma, and does not exceed 1 mm. in width. The dorso-ventral di-

ameter of the conch enlarges from 1.5 mm. at its apical end to 6.5 mm. at a point two and a half volutions farther up, increasing to 9 mm. at its larger end, as far as preserved. Successive volutions evidently were in contact with each other. The median part of the ventral side is distinctly elevated for a considerable width, and broadly channeled lengthwise. The specimen is a cast of the exterior of the conch. This exterior is ornamented with lateral ribs which are straight from the dorsal side to the ventro-lateral shoulders, and then curve moderately backward. Along the straight part of their course these ribs are narrow and sharply elevated, but they diminish rapidly in prominence along their ventral ends, disappearing before reaching the longitudinal ridges bordering the broad groove along the ventral side of the conch. Four ribs occur in a length of 8 mm., measured along the ventral outline of the conch where its dorso-ventral diameter is 7 mm., and 4 ribs occupy a length of 7 mm. where this diameter is about 5 mm. Wauwatosa, Wisconsin; in the Racine. No. 22930, Walker Museum, University of Chicago. Plate XXV, fig. 6.

5. **Ophidioceras welleri** Sp. nov.

Plate XXV, fig. 5

Ophidioceras welleri is characterized by the slow rate of enlargement of the conch dorso-ventrally, its depressed reniform cross-section, and its relatively numerous lateral ribs. The type consists of about four and three-quarters volutions. The exact size of the umbilical opening can not be determined but there is a possibility that this equalled 2 mm. in diameter. The dorso-ventral diameter increases from 4 mm. at a point one volution back from the larger end of the specimen to 5.5 at this larger end itself. The cross-section of the conch is reniform, the lateral diameter being almost 6 mm. where the dorso-ventral one is 5 mm. The dorsal impressed zone has a width of 2.5 mm., and the two salient lines bordering the longitudinal ventral groove are 1.5 mm. apart. At this point, moreover, 4 transverse ribs occupy a length of 6 mm. These ribs are relatively sharp-crested; they are straight from their dorsal end as far as the ventro-lateral

shoulders, and thence curve slightly backward, disappearing before reaching the salient lines bordering the ventral groove. The sutures of the septa curve slightly downward laterally. The concavity of these septa is distinct but not deep. The location of the siphuncle is central. The free end of the living chamber is at least 5 mm. long, departing from the preceding volution in the form of a tangent.

Occurrence.—Thornton, Illinois; in the Racine. No. 22939, Walker Museum, University of Chicago, holotype.

Named in memory of Stuart Weller.

CENTRORIZOCERAS Gen. nov.

Genotype: *Centrorizoceras slocomi* Foerste.

Conch enlarging at a rate sufficiently rapid and possessing a living chamber sufficiently long to suggest *Rizoceras*, but it is evenly though moderately curved along its living chamber, its cross-section is circular, and the location of its siphuncle is almost central, being only slightly ventrad of the center of the conch. The passage of the siphuncle through the septum at the base of the living chamber is so small that its segments probably also were relatively narrow and elongated, but this is uncertain.

In typical *Rizoceras* the conch is slightly curved along the lower part of the phragmacone, but the upper part of the phragmacone and all of the living chamber is relatively straight. The conch is slightly compressed laterally, the margin of the aperture curves downward both ventrally and dorsally, both curvatures being slight, that on the ventral side being both more narrow and more shallow. The siphuncle is located near the ventral side of the conch.

In *Codoceras* the general form is similar to that of *Rizoceras*, but it is that side of the conch which is concave along its lower part which is ventral, and the location of its siphuncle is slightly ventrad of the center of the conch, and therefore slightly nearer this concave side. Moreover, the siphuncle is relatively large, especially toward the top of the phragmacone, and its segments are distinctly nummuloidal here.

6. **Centrorizoceras slocomi** Sp. nov.

Plate I, fig. 1

Specimen consisting of almost all of a living chamber, but its aperture is not preserved. The chamber is curved lengthwise, the convex outline of its ventral side having a radius of 115 mm. The dorso-ventral diameter enlarges from 19 mm. at the base of the chamber to 32 mm. at its larger end, the interval being about 40 mm. The cross-section of the conch is essentially circular, the lateral diameter at the top of the specimen being about 1 mm. longer than the dorso-ventral one. The suture of the septum at the base of the specimen is straight and directly transverse. The concavity of this septum is 4 mm. The siphuncle is located slightly ventrad of the center of the conch, its exact location being 8 mm. from the ventral wall where the dorso-ventral diameter of the conch is 19 mm. The passage of the siphuncle through the septum at this point is remarkably small, equalling only 1.2 mm.

Occurrence.—Chicago, Illinois; in the Racine. No. 4622, Walker Museum, University of Chicago; holotype.

Named in honor of Arthur W. Slocom.

METARIZOCERAS Gen. nov.

Genotype: *Metarizoceras savagei* Foerste.

Conch erect, rapidly expanding as in *Rizoceras*, but its ventral outline is distinctly convex along the living chamber and its dorsal outline is faintly concave along the upper part of the phragmacone, chiefly owing to a faint gibbosity along mid-height of this chamber. The margin of the aperture curves faintly downward along the middle of its ventral side, but not dorsally. The siphuncle is located close to the ventral wall of the conch, and its segments appear to be oblong, rather than fusiform, in outline.

In typical *Rizoceras* the conch is straight, except along the lower part of the phragmacone. The ventral outline is not convexly curved, and there is no faint gibbosity at mid-height of the living chamber. The segments of the siphuncle are fusiform, tapering downward.

7. **Metarizoceras savagei** Sp. nov.

Plate I, figs. 2 A, B; 3

Conch breviconic, enlarging rapidly. The dorsal side is nearly straight, with a faint convexity along the living chamber. The ventral outline of the phragmacone is nearly straight as far up as the second camera below the living chamber. Above this point the ventral outline has a convex curvature with a radius of 65 mm. The maximum dorso-ventral diameter is at the aperture, but the maximum lateral diameter is at mid-height of the living chamber. At the base of the specimen the dorso-ventral diameter is 19 mm., and the lateral one is 18 mm. At the base of the living chamber the corresponding diameters are 31 mm. and 30 mm. At mid-height of this chamber they are 39 mm. and 37 mm., and at the aperture they are 41 mm. and 35 mm. About 11 camerae occur in a length equal to the dorso-ventral diameter at the top of the series counted. The sutures are almost directly transverse to the curving vertical axis of the conch, rising slightly ventrally toward the upper part of the phragmacone. Faint lines of growth along the upper part of the living chamber suggest that there was a shallow hyponomic sinus on the ventral side of the aperture. No. 81421, in the U. S. National Museum; holotype. Plate I, figs. 2 A, B.

A second specimen attains a dorso-ventral diameter of 45 mm. at the aperture. No. 22812A, Walker Museum, University of Chicago. Plate I, fig. 3.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

Named in honor of Thomas E. Savage.

8. **Metarizoceras robustum** Sp. nov.

Plate I, fig. 4

Specimen 52 mm. long, consisting of a living chamber 39 mm. long, to which 3 camerae are attached. Compared with typical *Rizoceras savagei*, the camerae are longer and the sutures of the septa curve slightly downward laterally. The dorsal outline of the living chamber is slightly convex, and the continuation of this

outline along the lower part of the living chamber and the upper part of the phragmacone is slightly concave. At the base of the specimen the dorso-ventral diameter is 31 mm., and the lateral one is 26.5 mm. At the base of the living chamber the corresponding diameters are 38.5 mm. and 33 mm. At the aperture the dorso-ventral diameter is 50 mm. The upper portion of the lateral walls of the living chamber curve slightly inward, as in typical *Metarizoceras savagei*. Faint traces of transverse lines of growth suggest the presence of a distinct but shallow hyponomic sinus.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. S-191, Savage collection; holotype.

9. **Metarizoceras depauperatum** Sp. nov.

Plate I, figs. 5 A, B

Similar in form to *Metarizoceras savagei*, but much smaller in size and with fewer camerae in a length equal to the dorso-ventral diameter. At the base of the living chamber the dorso-ventral diameter is 19 mm., and the lateral one is 17 mm. At the aperture, 20 mm. farther up, the corresponding diameters are 24.5 mm. and 21 mm. A broad transverse constriction along the top of the living chamber extends downward from the margin of the aperture 5 mm. Three camerae occupy a total length of 9 mm. The sutures of the septa rise both dorsally and ventrally into very low and slightly angulate saddles. The siphuncle is close to the ventral wall of the conch.

Occurrence.—Chicago, Illinois; in the Racine. No. 22905, Walker Museum, University of Chicago; holotype.

10. **Metarizoceras dispandum** Sp. nov.

Plate I, fig. 7

Specimen 42 mm. long, of which 17 mm. belongs to the phragmacone; characterized by the rapid expansion of the living chamber and the distinct angulation of the sutures of the septa along the median line of the ventral side of the phragmacone. The

cross-sections of the phragmacone are circular. The conch is erect, enlarging more rapidly along the living chamber than along the phragmacone. The latter enlarges from a diameter of 14.5 mm. at its base to 23.5 mm. at its top, its apical angle being 25 degrees. The living chamber enlarges at an apical angle of 40 degrees for a length of 16 mm. above its base, where it attains a diameter of 35 mm. Above this point the vertical lateral outlines of the chamber curve convexly, though the living chamber continues to enlarge, but more slowly than along its lower half. About 10 camerae occur in a length equal to the diameter of the conch at the top of the series counted. The sutures are directly transverse to the vertical axis of the conch, and are straight except along the median part of the ventral side, where they curve slightly upward. The siphuncle is almost in contact with the ventral wall of the conch.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 1119, University of Illinois; holotype.

11. **Metarizoceras erectum** Sp. nov.

Plate I; figs. 6 A, B; plate II; figs. 1 A, B, C

Conch enlarging dorso-ventrally at an angle of 23 degrees along the phragmacone, diminishing to 20 degrees along the upper part of the living chamber. Compared with *Metarizoceras savagei*, the rate of enlargement of the conch is less, and the convexity of its ventral outline also is less. At the base of the eighth camera beneath the living chamber the dorso-ventral diameter is 19 mm., enlarging to 32 mm. at the base of this chamber, and to 41 mm. at its aperture. The corresponding lateral diameters are 19 mm., 30 mm., and 36 mm. About 10 camerae occur in a length equal to the dorso-ventral diameter at the top of the series counted. The sutures of the septa are directly transverse to the vertical axis of the conch, the latter being almost straight. The siphuncle is near the ventral wall of the conch. The surface of the cast of the interior of the conch is faintly marked by very faint, low and broad, annular transverse markings, of which 10 occur in a length of 20 mm. along the ventral side of the living chamber. These

indicate the presence of a very shallow hyponomic sinus. No. S-190, Savage collection; holotype. Plate I; figs. 6 A, B.

A second specimen in the Savage collection consists of only a phragmacone. In this, the upper part of the siphuncle is 2 mm. in diameter and its nearest part is 1 mm. distant from the ventral wall of the conch. The vertical ventral outlines of the segments of the siphuncle are evenly convex, while their dorsal outlines are scalariform. These dorsal outlines are almost straight, but slant so as to be more distant from the ventral wall of the conch at their upper ends, while their lower ends are nearer this wall.

A third specimen suggests that the inner surface of the shell surrounding the living chamber was thickened slightly for a length of 4 mm. along its upper part. This chamber is 40 mm. long and shows traces of faint transverse annulations unusually well. No. 81422, in the U. S. National Museum. Plate II, figs. 1 A, B, C.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

CYRTORIZOCERAS Hyatt

Genotype: *Cyrtoceras minneapolis* Clarke, Geol. Minnesota, 3, pt. 2, 808, pl. 59, figs. 1–8 (1897); *Cyrtorizoceras minneapolis* Hyatt, in Zittel-Eastman's Text-book of Paleontology, 529 (1900).

Breviconic cyrtocones, laterally compressed, living chambers not contracted dorso-ventrally, and usually not contracted laterally. Sutures of septa curving downward laterally, forming broad lateral lobes and distinctly narrower dorsal and ventral saddles, the latter being much more conspicuous. The siphuncle is located close to the ventral wall of the conch, and its segments are fusiform, narrowing downward. The surface of the shell is smooth or transversely striated, but not annulated.

In his Genera of Fossil Cephalopods, published in 1884, Hyatt included forms of this type in his more broadly conceived genus *Maelonoceras*. However, in that edition of Zittel-Eastman's Text-book of Paleontology which was published in 1900 he confined the term *Maelonoceras* to those forms which resembled the

genotype in having the lateral edges of the gerontic aperture curve inward, resulting in a pear-shaped aperture. For those forms in which this aperture did not contract, or contracted but slightly, he proposed the name *Cyrtorizoceras*.

The name *Oonoceras* was proposed by Hyatt, in 1884, for Silurian forms which differed from *Cyrtorizoceras* chiefly in the very slow rate of enlargement of the conch and in the annulation of the surface of the shell. This shell appears to have been very much thicker than in typical *Cyrtorizoceras*, the casts of the interior of the shell showing no trace of annulation, or being only weakly annulated, chiefly ventrally. This leaves unplaced a considerable number of Silurian conchs which differ from typical *Oonoceras* chiefly in their more rapid rate of enlargement. Among the species here described, those originally described under the names *Cyrtoceras dardanum* and *Cyrtoceras fosteri* are conspicuously annulated only exteriorly, casts of the interior being either smooth or weakly annulated, usually only ventrally. The other species here described also may have been annulated exteriorly, but no trace of annulation is shown by casts of the interior. Eventually it may prove desirable to separate these more rapidly expanding Silurian forms both from *Cyrtorizoceras* and from *Oonoceras*. Provisionally they are retained in *Cyrtorizoceras*, where the species originally described as *Cyrtoceras dardanum* and *Cyrtoceras fosteri* are now listed in Bassler's Bibliographic Index of American Ordovician and Silurian Fossils.

12. **Cyrtorizoceras fosteri** (Hall)

Plate VIII, fig. 3; plate IV, figs. 3, 4; plate III, figs. 1 A, B; also text fig. 1

Cyrtoceras fosteri Hall, Report of Superintendent, Geol. Surv. Wisconsin, for 1860, 41 (1861); 20th Rep. New York State Cab. Nat. Hist., 349, pl. 16, figs. 11–13 (1868).

The holotype is exposed only along its ventral and lateral sides. The radius of convex curvature of its ventral outline is 50 mm. along the lower half of that part of the phragmacone which is preserved, changing to 70 mm. along the upper part of the phragma-

cone and the living chamber. Of this chamber a length of 16 mm. remains. The lateral diameter enlarges from 13 mm. near the lower end of the specimen to 20 mm. at a point 42 mm. farther up, measured along its ventral outline. At the top of the phragmacone, where the lateral diameter is 17 mm., the dorso-ventral one is estimated at 22.5 mm. In that case about 7.5 camerae occur in a length equal to the dorso-ventral diameter of the conch, if counted along the ventral outline. From the middle of the lateral sides of the conch the sutures of the septa curve conspicuously upward in a ventrad direction, forming ventral saddles which tend to become angular along their median part along the upper portion of the phragmacone. The cast of the interior of the living chamber retains faint traces of transverse wrinkles curving downward ventrally, evidently parallel to former stages of the hyponomic sinus. At the base of two camerae at mid-height of the phragmacone the location of the siphuncle close to the ventral wall of the conch may be seen. Plate VIII, fig. 3; text fig. 1.

1. CYRTORIZOCERAS FOSTERI (HALL)

Lateral view, partially exposed, with ventral outline on left.

Occurrence.—Bridgeport, in the southern part of Chicago, Illinois; in the Racine. No. 2123, American Museum of Natural History; holotype.

Hall's lateral view of this type gives a very exact representation of the curvature of the sutures of the septa. His ventral view overaccentuates both the transverse curvature of the conch ventrally and the degree of angularity of the sutures of the septa along the upper part of the phragmacone.

Ohio specimens.—Cyrtoceracone strongly curved, enlarging toward the aperture, but not rapidly, and chiefly in a dorso-ventral direction. The largest phragmacone retains 30 camerae and measures 72 mm. along its ventral outline. The radius of curvature of its dorsal outline varies from 18 mm. along its apical third

to 70 mm. along its upper third. Along its ventral side this radius varies from 30 mm. along its lower third to 60 mm. along its upper third. The conch is strongly compressed laterally, its lateral sides being distinctly flattened. In one specimen, with a dorso-ventral diameter of 26.5 mm., the lateral diameter is 20 mm. The ventral part of the cross-section is slightly more narrowly rounded than its dorsal part.

The sutures of the septa curve moderately downward laterally, the maximum downward curvature being located seven-eighteenths of the dorso-ventral diameter of the conch from its dorsal side. In a dorsad direction the sutures rise only moderately, but ventrally they rise more strongly, curving more directly outward on approaching the ventral side of the conch, resulting in a slightly sigmoid curvature. The ventral saddles are distinctly higher than the dorsal ones. The siphuncle is narrow and its segments enlarge but slightly within the camerae, presenting fusiform outlines. In the specimen with a dorso-ventral diameter of 26.5 mm., mentioned above, the diameter of the siphuncle is about 1.7 mm., and its distance from the ventral wall of the conch also is 1.7 mm.

Along the ventral side of the phragmacone the sutures are crossed diagonally by faint transverse wrinkles, regularly spaced, 2 or 3 mm. apart, probably corresponding to more conspicuous transverse annulations on the surface of the shell; but these wrinkles disappear on the lateral sides of casts of the interior, and in some specimens can not be detected even ventrally. They are most readily detected along the median part of the ventral side of casts of the interior, especially under cross-illumination. When viewed from the lateral side of the conch these annulations cross the sutures of the septa at angles of about 22 degrees, sloping downward in a ventrad direction. Evidently they indicate the presence of a relatively deep hyponomic sinus.

The length of the largest living chamber found is 20 mm. above the lowest part of the suture of the septum at its base. It is faintly constricted laterally about 13 mm. above this base and then widens out again slightly toward the aperture. In a dorso-ventral direction its constriction is almost imperceptible.

Occurrence.—From the Moodie quarry, in the southeastern

part of Wilmington, Ohio; in the Cedarville dolomite. Those figured on plate IV (figs. 3, 4) are from the Austin collection, in the U. S. National Museum. Additional specimens are preserved in the collection of Dr. L. D. Welch, deposited in Wilmington College.

Port Byron specimens.—Several fragments, closely resembling *Cyrtorizoceras fosteri*, are at hand, but none of these is sufficiently long to give exact information as to the amount of lengthwise curvature of the conch. One specimen consists of the living chamber with 4 camerae still attached. The living chamber is at least 16 mm. long. At its base the dorso-ventral diameter is 23 mm. and the lateral one is 17 mm. At mid-length of the chamber both diameters are 1 mm. longer. At the aperture the dorso-ventral diameter is 23 mm. again, but the lateral one remains at 18 mm. The length of the camerae preserved suggests the original presence of 7 camerae in a length equal to the dorso-ventral diameter of the conch at the top of the series counted. The sutures of the septa curve strongly downward laterally, the ventral saddles rising distinctly higher than the dorsal ones. The diameter of the siphuncle is estimated at about 2 mm. at its maximum width within the camerae, and its center is 2 mm. distant from the ventral wall of the conch. The exterior of the shell evidently was marked by transverse annulations. These probably were most distinct ventrally and became more faint or obsolete laterally. At least, on casts of the interior of the conch these annulations can be detected only ventrally. About 9 annulations occur in a length equal to the dorso-ventral diameter of the conch, when counted along its ventral outline.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81423, in the U. S. National Museum. Fragments of the phragmacone, including 7 or 8 camerae, occur in the Savage collection. Plate III, figs. 1 A, B.

13. **Cyrtorizoceras pusillum** Sp. nov.

Plate XXV, fig. 9

Cyrtoceras pusillum Hall, 20th Rep. New York State Cab. Nat. Hist., 357 (1869); revised edition, 407 (1870).

Specimen 43 mm. long measured along its ventral outline. Of

this length the living chamber occupies 12 mm., the uppermost camera 3 mm., and the remainder is the impression left by the exterior of one side of the phragmacone. The radius of curvature of the convex ventral outline is 20 mm. along most of the phragmacone, and 25 mm. along the upper part of the phragmacone and the living chamber. The dorso-ventral diameter enlarges from 7.5 mm. near the base of the specimen to 13 mm. at the base of the camera immediately beneath the living chamber, and to 16 mm. at the highest part of this chamber preserved, the corresponding intervals being 23 mm. and 12 mm. At the base of the camera mentioned the lateral diameter is 11 mm. Judging from the single camera preserved, about 4.5 camerae occupied a length equal to the dorso-ventral diameter of the conch. The siphuncle is close to the ventral wall of the conch but not in contact with the latter. The chief characteristic of this species is its small size, its strong lengthwise curvature, and the relative tallness of its camerae ventrally, compared with the dorso-ventral diameter of the conch.

Occurrence.—Racine, Wisconsin; in the Racine. Specimen in the same fragment of rock as that containing *Lechritrococeras desplainense* and *Cyclorizoceras brevicorne* (Hall). *Cyrtorizoceras pusillum* is not listed in catalogue of the American Museum of Natural History, but the other two species named are numbered 2126 and 2118 respectively. The occurrence of *Cyclorizoceras* in this association is recorded by Hall in the revised edition of the report cited above, in the remarks following the description of that species of this genus which he described under the name *Cyrtoceras brevicorne*.

14. **Cyrtorizoceras dardanum** (Hall)

Plate III, fig. 4

Cyrtoceras dardanum Hall, Report of Superintendent, Geol. Surv. Wisconsin, 43, (1861); 20th Rep. New York State Cab. Nat. Hist., 349, pl. 17, fig. 3 (1868).

The specimen here selected as the type consists of a living chamber with 15 camerae still attached. Its length along its

ventral outline is 98 mm., 25 mm. of this length being occupied by the living chamber. The radius of curvature of this convex outline varies from 50 mm. along the lower half of the specimen to 70 mm. along its upper half. The dorso-ventral diameter enlarges from 16 nm. at its base to 31 mm. at the base of the living chamber, retaining this diameter as far as the aperture. The corresponding lateral diameters are 13 mm., 23 mm., and 21 mm. The number of camerae in a length equal to the dorso-ventral diameter of the conch is five and one-half. The sutures of the septa are nearly directly transverse to the curving central axis of the conch along its dorsal half, but curve increasingly upward ventrally, with a slight reversal of curvature near its ventral outline. The segments of the siphuncle are fusiform in outline, and attain a diameter of 3 mm. where the dorso-ventral diameter of the conch is 24 mm., the distance of the siphuncle from the ventral wall slightly exceeding 1 mm. A considerable part of the shell is preserved; its thickness was about half a millimeter, and its surface apparently was smooth.

Occurrence.—Wauwatosa, Wisconsin; in the Racine. No. 2122-A, American Museum of Natural History; holotype. The original locality label still is attached to the specimen.

Remarks.—Closely similar, but not identical, specimens from the Cedarville dolomite of southwestern Ohio show traces of annulations along the ventral side of casts of the interior of the conch.

15. **Cyrtorizoceras halli** Sp. nov.

Plate III, fig. 3

Cyrtoceras dardanum Hall, 20th Rep. New York State Cab. Nat. Hist., 406, pl. 17, figs. 4, 5, not fig. 3 (1868).

Phragmacone consisting of 18 camerae; strongly compressed laterally, the dorso-ventral diameter near the top of the specimen being 40 mm., and the lateral one 32 mm. The convex curvature of the ventral outline has a radius of 77 mm., that of the concave dorsal outline being 42 mm. The most characteristic feature of this phragmacone is the straightness of the sutures of its

septa. These septa are rather strongly concave. The siphuncle is fusiform, enlarging to about 3.5 mm. within the camerae; its distance from the ventral wall of the conch is 1.5 mm. The number of camerae within a length equal to the dorso-ventral diameter of the conch equals 4.5 near the lower end of the specimen, when counted along its ventral outline, increasing to 5 near its top. No indications of surface markings are preserved, the specimen being a cast of the interior of the conch. Compared with typical *Cyrtorizoceras dardanum*, the conch of this species enlarges much more slowly.

Occurrence.—Wauwatosa, Wisconsin; from the Racine. No. 2122-B, American Museum of Natural History; holotype.

Named in memory of James Hall.

Waukesha specimen.—A cast of the interior of a conch, retaining a considerable part of the living chamber, with 15 camerae still attached, may belong to *Cyrtorizoceras halli*, though increasing at a somewhat more rapid rate in diameter dorso-ventrally. Since its uppermost camera is distinctly shorter than the rest, this specimen is regarded as mature. No. 22929, Walker Museum, University of Chicago. From the Racine.

16. **Cyrtorizoceras fultonense** (Meek and Worthen)

Plate III, figs. 2 A, B

Cyrtoceras fultonensis Meek and Worthen, Geol. Surv. Illinois, 6, 506, pl. 25, figs. 6 a, b.

Compared with *Cyrtorizoceras dardanum*, the conch of *Cyrtorizoceras fultonense* is larger, wider laterally, and less curved lengthwise. The curvature of its convex ventral outline has a radius of 65 mm. That of the concave dorsal outline is 100 mm. along the phragmacone; this curvature increases on approaching the base of the living chamber, and becomes quite small along the living chamber. The living chamber contracts near the aperture, the dorso-ventral contraction being most in evidence along the ventral side of the chamber. There is also a lateral compression. At the base of the specimen the dorso-ventral diameter is 22 mm. and the lateral one is 20 mm. At the base of the living chamber

the corresponding diameters are 43 mm. and 40 mm. The sutures of the septa curve downward laterally, the depth of the lateral lobes equalling slightly more than 2 mm. at the base of the living chamber. The maximum depth of these lobes here is 18 mm. from the dorsal side of the conch. The septa are moderately concave. The siphuncle is only slightly over half a millimeter from the ventral wall of the conch. Its segments are fusiform. At the fifth camera beneath the living chamber its dorso-ventral diameter is fully 3 mm. while its lateral diameter is slightly less.

Occurrence.—Fulton city, 16 miles north of Port Byron, Illinois, from a buff limestone at the base of the Niagaran exposures. No. 11728, University of Illinois; holotype.

17. **Cyrtorizoceras byronense** Sp. nov.

Plate II, figs. 2 A, B, C

Compared with *Cyrtorizoceras dardanum*, the living chamber of *Cyrtorizoceras byronense* is much more strongly curved, especially dorsally. The holotype consists of a living chamber with one camera attached. Both the ventral and the dorsal outline have a radius of vertical curvature of 70 mm. The dorso-ventral diameter increases from 37 mm. at the base of the specimen to 43 mm. at a point two-thirds of the height of the living chamber above its base, and then retains the same diameter as far as the aperture. The lateral diameter at the base of the specimen is estimated at 34 mm. No. 81424, in the U. S. National Museum; holotype. Plate II, figs. 2 A, B, C.

A second specimen, also including the living chamber and one camera, enlarges from a diameter of 35 mm. at its base to 42 mm. at its top, its lengthwise curvature being essentially the same as in the preceding specimen. Savage collection.

A fragment of a phragmacone, possibly belonging to the same species, includes 4 camerae, indicating that the number of camerae formerly occupying a length equal to the dorso-ventral diameter is 5, where this diameter is 35 mm. No. 81424 a, U. S. National Museum.

Occurrence.—Port Byron. Illinois; in the Port Byron dolomite.

18. **Cyrtorizoceras auctidomum** Sp. nov.

Plate II, figs. 3 A, B; 4

Compared with *Cyrtorizoceras fultonense*, the living chamber of *Cyrtorizoceras auctidomum* is short and broad. This living chamber expands but slightly both laterally and dorso-ventrally as far as the aperture. At its base the dorso-ventral diameter is 36.5 mm. and the lateral one is estimated at 30.5 mm. At the top of the specimen the corresponding diameters are 42 mm. and 37 mm. Along the upper end of the chamber, for a length varying from 5 mm. on its dorsal side to 7 mm. on its ventral side, there is a very faint contraction of the cast of the interior of the chamber. Along the median part of its ventral side, the margin of the aperture curves distinctly downward into a shallow hyponomic sinus. The suture of the septum at the base of the chamber is almost directly at right angles to the vertical outline of the dorsal side of the chamber, but curves distinctly upward ventrally. The siphuncle is close to the ventral wall of the conch. No. 81425, U. S. National Museum; holotype. Plate II, fig. 3 A, B.

A closely similar specimen, but of smaller size, has a dorso-ventral diameter increasing from 33 mm. at its base to 39 mm. at its top, its length being 27 mm. No. 81425 a, U. S. National Museum. Plate II, fig. 4.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

19. **Cyrtorizoceras longidomum** Sp. nov.

Plate IV, figs. 1 A, B

This species is characterized chiefly by the unusual length of its living chamber, and the slight curvature of the latter. This curvature is greatest near the top and bottom of the chamber and is only slight along its intermediate part. At the base of the specimen its dorso-ventral diameter is 37 mm. and its lateral diameter is estimated at 31 mm., the maximum length of the chamber being 53 mm. Within this length the two diameters remain essentially the same as at the base of the chamber, though

there is a slight lateral enlargement at its top and also a slight enlargement along the dorsal side of the aperture. The passage of the siphuncle is 2 mm. from the ventral wall of the conch.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81426, U. S. National Museum; holotype.

20. **Cyrtorizoceras ruedemanni** Sp. nov.

Plate IV, figs. 2 A, B; 5; 6 A, B

Cyrtorizoceras ruedemanni is characterized by the strong curvature of the concave dorsal outline of the living chamber and by the angulation of the sutures of the septa along the median part of the ventral side of the conch. One of the cotypes consists of a living chamber with a single camera still attached. The radius of curvature of the concave dorsal outline is 20 mm. along the lower part of this chamber, the curvature becoming distinctly less farther up. At the base of the specimen its dorso-ventral diameter is 32 mm., its lateral diameter being 29 mm. At a point 34 mm. farther up, the corresponding diameters are 39 mm. and 37 mm. The sutures of the septa curve slightly downward laterally, rising more strongly ventrally than dorsally. No. 192A, Savage collection; Plate IV, figs. 2A. Another specimen, No. 192B (plate IV, fig. 2 B), shows the same strong concave curvature of the dorsal outline along the lower part of the living chamber, but the cross-section of the conch is less compressed laterally. A third specimen, No. 194 (plate IV, fig. 5), consists of a phragmacone including 6 camerae, and showing a tendency on the part of the sutures of the septa to be angulate along the median part of the ventral side of the conch.

This tendency toward angulation of the median part of the ventral side of the sutures of the septa is shown also by a specimen, No. 22896 (plate IV, figs. 6 A, B), in Walker Museum, University of Chicago. This specimen consists of the lower part of the living chamber and 5 camerae still attached. From the latter it is evident that originally about 5.5 camerae occupied a length equal to the dorso-ventral diameter of the conch at the top of the series counted.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. Specimens no. S-192A, 192B, and 194, in the Savage collection are cotypes

Named in honor of Rudolf Ruedemann.

21. **Cyrtorizoceras unguicurvatum** Sp. nov.

Plate V, figs. 2, 3, 4

Cyrtorizoceras unguicurvatum differs from *Cyrtorizoceras ruedemanni* in its smaller size, the conch being more compressed laterally, and more strongly curved lengthwise, and the sutures of the septa being more evenly rounded ventrally, instead of angulate along the median part of the ventral side of the conch. Finally, the ventral saddles rise somewhat higher.

The holotype consists of a living chamber with 4 camerae still attached. The radius of curvature of the concave dorsal outline is approximately 10 mm. The corresponding radius of the convex dorsal outline varies from 35 mm. along the phragmacone to 25 mm. along the lower part of the living chamber. At the base of the specimen the dorso-ventral diameter is 22 mm., and the lateral one is 18 mm., the corresponding diameters at the base of the living chamber being 29 mm. and 25 mm. The sutures of the septa rise increasingly upward on approaching the top of the phragmacone. No. 193B, Savage collection; holotype. Plate V, fig. 2.

A second specimen, No. 193A, consists of the basal part of the living chamber with 5 camerae still attached. These 5 camerae occur in a length equal to the dorso-ventral diameter of the conch at the top of the series counted. The sutures of the septa curve slightly downward laterally, and the ventral saddles rise to relatively greater heights on approaching the living chamber. The median part of these saddles is evenly rounded, rather than distinctly angulate. Plate V, fig. 4.

A third specimen, No. 204 (plate V, fig. 3), is of interest because two of the sutures curve downward dorso-laterally. Similar features are shown by the sutures of two specimens of *Phragmoceras wortheni* figured on plate XVIII.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. All in the Savage collection.

CYCLORIZOCERAS Gen. nov.

Genotype: *Cyrtoceras brevicorne* Hall.

Conchs similar to the species here assigned to *Cyrtorizoceras* in the fusiform outline of the segments of its siphuncle, and in its lengthwise curvature, but differing in its distinctly circular cross-section

In *Cyclostomiceras*, the segments of the siphuncle present concave vertical outlines, as in the Holochoanoidea; moreover, the conchs are almost erect.

22. Cyclorizoceras brevicorne (Hall)

Plate XXV, fig. 8

Cyrtoceras brevicorne Hall, 20th Rep. New York State Cab. Nat. Hist., 356, pl. 17, figs. 8, 9 (1868).

Specimen 53 mm. long, measured along its ventral outline. It consists of a cast of the interior of the living chamber and of the camera immediately beneath; the impression of the exterior of the dorsal and dorso-lateral part of the phragmacone immediately beneath; and, at its base, a trace of another camera. The radius of curvature of the convex ventral outline is 50 mm. Along this outline the living chamber occupies a length of 25 mm., and the uppermost camera of nearly 4 mm. The specimen enlarges in a lateral direction from a diameter of 5 mm. at its base to 18.2 mm. at the base of the living chamber, and to 28 mm. at the aperture, the corresponding intervals being 28 mm. and 25 mm. The cross-section of the living chamber at its base and mid-height is circular, and this cross-section also probably continues up to the aperture. The sutures of the septa curve only slightly downward laterally, and rise only moderately in a ventrad direction. The concavity of the septum of the uppermost camera is 3 mm. The siphuncle is almost in contact with the ventral wall of the conch. Its segments are fusiform in outline, that in the uppermost camera having a diameter of 2.2 mm. It can not be determined whether

the margin of the aperture curves slightly downward along its ventral outline or not. The surface of the specimen retains no trace of surface markings.

Occurrence.—Racine, Wisconsin; in the Racine. Specimen no. 2118, American Museum of Natural History; holotype.

CLIONYSSICERAS Gen. nov.

Genotype: *Clionyssiceras petilum* Foerste.

Conch apparently but slightly curved, only the living chamber and one camera are known, but in this part of the conch the ventral outline is slightly more convex than the dorsal one. The cross-section is almost circular. The most characteristic feature of this conch, as far as known, is the strong downward slope of the suture of the septum at the base of the living chamber in a dorsad direction. The siphuncle is small, close to the ventral wall of the conch, and apparently inflated within the camerae in a cyrtochoanitic manner.

In *Chicagooceras*, the direction of the slope of the sutures of the septa is ventrad, instead of dorsad. In other respects, the two genera may have been approximately similar in form.

23. **Clionyssiceras petilum** Sp. nov.

Plate V, figs. 5 A, B

Specimen consisting of a living chamber, apparently with a single camera still attached. The conch apparently was but slightly curved. Its dorsal outline is only faintly convex. Its ventral outline is more strongly convex, with a radius of curvature of 50 mm. The living chamber enlarges slightly at mid-height. At its base the dorso-ventral diameter is almost 11 mm., increasing to 13 mm. at mid-height, and diminishing to slightly less than 13 mm. at the aperture. The lateral diameter increases from 11 mm. at the base to 14 mm. at mid-height, above which it diminishes slightly. The suture of the septum at the base of the living chamber slopes in a dorsad direction at an angle of 10 degrees with a horizontal plane. The siphuncle is located close to the ventral wall of the conch but not in actual contact with the same.

Its segments appear to enlarge abruptly within the camerae in a cyrtochoanitic manner.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81427, U. S. National Museum; holotype.

CHICAGOOCERAS Foerste and Savage

Genotype: *Chicagooceras welleri* Foerste and Savage, Jour. Sci. Lab. Denison Univ. 22, 48, pl. 24, fig. 4 (1927).

Conch erect, relatively slender, largest at the base of the living chamber, its dorsal outline being only faintly convex, while the convexity of its ventral outline is distinct. Cross-section nearly circular along the phragmacone, becoming slightly depressed dorsoventrally along the upper part of the living chamber. The sutures of the septa slope downward in a ventrad direction. The siphuncle appears to be small and slender and is located moderately ventrad of the center of the conch.

24. **Chicagooceras welleri** Foerste and Savage

Plate V, figs. 1 A, B

This species is described sufficiently in the publication cited above. In addition to the lateral view already published, a dorsal view here is presented. These figures will serve to indicate the directly opposite slope of the sutures of the septa in *Chicagooceras* and in *Clionyssiceras*. In the lateral view of *Chicagooceras welleri* (pl. V, fig. 1A), the ventral outline is on the left side of the figure; in that of *Clionyssiceras petilum* (pl. V, fig. 5A), it is on the right. If the latter figure had been oriented like the former, the difference in direction of slope of the sutures would be more apparent.

Occurrence.—Chicago, Illinois; in the Racine dolomite. Specimen no. 21891, Walker Museum, Univ. of Chicago; holotype.

SAVAGEOCERAS Gen. nov.

Genotype: *Savageoceras transversale* Foerste.

Conchs, as far as known, cyrtoconic and rapidly expanding, rather than trochoceroid; depressed dorso-ventrally, and more or less trapezoidal in cross-section. The ventral side is wider than

the dorsal one, the lateral sides converging in a dorsad direction. Moreover, the ventral side tends to be flatter in cross-section than the dorsal one. The sutures of the septa curve slightly downward laterally and also ventrally, apparently rising at the ventro-lateral shoulders of the conch into low broad saddles. The siphuncle is central in location, and its passage through the septum at the top of the genotype is sufficiently large to suggest that the diameter of the segments within the camerae may have been even larger. The surface of the shell is crossed by rib-like annulations, which are low and vaguely defined dorsally, but increase in prominence toward the ventro-lateral shoulders of the conch, where they are most conspicuous. Ventrad of these shoulders the annulations rapidly become less prominent, and along the greater part of the ventral side of the conch they are very low and inconspicuous. The downward curvature of these annulations was relatively rapid at earlier stages of growth of the conch, but became less at later stages, indicating that the conspicuous hyponomic sinus became broader and more shallow with increasing age. In addition to these annulations there are numerous transverse striae, parallel to the latter.

Named in honor of Thomas E. Savage.

25. **Savageoceras transversale** Sp. nov.

Plate V, figs. 6 A, B

Specimen consisting of a phragmacone 135 mm. long on its ventral outline; enlarging from a lateral diameter of 32 mm. at its base to 66 mm. at its top, the corresponding dorso-ventral diameters being estimated at 31 mm. and 60 mm. The cross-section of the conch is slightly trapezoidal, the ventral side appears broader and flatter than the dorsal one, and the lateral sides converge in a dorsad direction. This appearance is due chiefly to the prominence of the transverse rib-like annulations along the ventro-lateral shoulders of the conch, and their weakness ventrally and dorso-laterally. Dorsally, they become obsolete. About 5 annulations occur in a length equal to the lateral diameter of the conch at the top of the series counted. Three camerae occur in a

length equal to the lateral diameter along the lower part of the specimen, this number increasing to 4 in a corresponding length near its top. The sutures of the septa are relatively straight, but rise moderately in a ventrad direction. The concavity of the septum at the top of the specimen is 12 mm. The siphuncle appears to be central in location, but nothing definite is known of its structure. The shell is about 1 mm. thick, and its surface is ornamented by transverse raised ilnes parallel to the annulations, about 12 lines in a length of 10 mm. along the middle of the lateral sides at mid-length of the specimen.

Along the smaller end of the specimen the radius of curvature of its convex ventral outline is 70 mm., suggesting that the complete conch, including the living chamber, may have been slightly longer than a single volution. There is no trace of a dorsal impressed zone.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 197, in the Savage collection; holotype.

26. **Savageoceras trapezoidale** Sp. nov.

Plate VI, figs. 1 A, B

Specimen consisting of the lower part of the living chamber, with 2 camerae still attached. Of the ventral side of the living chamber a length of 55 mm. remains. The upper camera is 16 mm. long, and the lower one measures 13 mm. There is no evidence that the conch was mature. The radius of curvature of its convex ventral side is 85 mm. The dorso-ventral diameter enlarges from 36 mm. at its base to 47 mm. at a ventral interval of 50 mm. The complete conch probably did not form an entire volution, but may have resembled in outline the type of *Uranoceras dyeri* (Jour. Sci. Lab. Denison Univ. 21, pl. 7, fig. 1, 1925)). The lateral diameter enlarges from 39 mm. at the base of the specimen to 47 mm. at a point 50 mm. farther up. The cross-section of the conch is faintly trapezoidal, chiefly owing to the flattening of its ventral side, and the slight increase in prominence of the annulations at the ventro-lateral shoulders. The dorsal side is slightly more narrowly rounded than the ventral one, the lateral

sides converging slightly in a dorsad direction. Originally about 3 camerae occupied a length equal to the lateral diameter of the conch. The sutures of the septa curve slightly downward ventrally and dorso-laterally, and rise slightly at the ventro-lateral shoulders. The concavity of the septa is 8 mm. The center of the siphuncle is 12.5 mm. from the ventral wall of the conch. There is no trace of a dorsal impressed zone. The annulations curve strongly downward laterally and ventrally. They are faint or obsolete dorsally, become slightly more distinct dorso-laterally, are most distinct ventro-laterally, and again are faint across the entire width of the ventral side. No trace of the ornamentation of the shell, aside from annulations, remains.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 198 Savage collection; holotype.

Remarks.—This species differs from *Savageoceras transversale* in the much less rapid rate of enlargement of the conch, and in the fainter development of the transverse annulations ventro-laterally.

BICKMORITES Foerste

Genotype: *Lituites bickmoreanus* Whitfield, Bull. Amer. Mus. Nat. Hist., 1, 191, pl. 21, figs. 1–3 (1885); *Bickmorites bickmoreanum* Foerste, Jour. Sci. Lab. Denison Univ., 21, 47, pl. 19, figs. 1–3; pl. 20, fig. 1 (1925).

Gyroceracones more or less compressed laterally, with prominent transverse ribs, which curve strongly backward, especially along the ventral side of the conch. The sutures of the septa curve distinctly downward laterally. The siphuncle is located slightly ventrad of the center of the conch. Parallel to the oblique rib-like annulations there apparently were transverse striae, at least in the genotype. At gerontic stages of growth, this genotype looses its ribs and only the relatively coarse transverse striae remain.

27. **Bickmorites welleri** Sp. nov.

Plate VI, figs. 2 A, B

Conch known at present only from its living chambers which are free from contact with preceding volutions; at least, no traces

of a dorsal impressed zone remain. In the holotype the radius of curvature of the convex ventral outline is 75 mm. The cross-section of the conch is slightly compressed laterally. At the base of the living chamber the dorso-ventral diameter is 34 mm. and the lateral one is 32.5 mm. measured at the crest of the annulations, but 30 mm. when measured at the intermediate grooves. At the top of the specimen, 100 mm. farther up along its ventral outline, the corresponding diameters are 38 mm., 38 mm. and 35 mm. Three and a half annulations occur in a length equal to the dorso-ventral diameter of the conch. These annulations slope diagonally and somewhat sinuously downward from its dorsal side toward the ventro-lateral angle. At this point the annulations curve rather abruptly and very steeply backward, forming deep V-shaped curves whose basal angles are weakly defined or entirely obsolete. The annulations are weak dorsally, but increase in strength laterally, where they form bold ribs which are most conspicuous ventro-laterally. Ventrad of these angles they rapidly decrease in size, and are almost entirely obsolete along the greater part of the width of the ventral side. The suture of the septum at the base of the living chamber curves distinctly downward. The siphuncle apparently is central in location. Compared with typical *Bickmorites bickmoreanum*, the ribs of the the species described here are much more prominent laterally, and much fainter ventrally.

Occurrence.—Hawthorne, Illinois, west of Chicago; in the Racine. Collected by the writer. Holotype.

Named in memory of Stuart Weller.

TROCHOCERAS Barrande

Genotype: *Trochoceras davidsoni* Barrande, Systeme Silurien du Centre de la Boheme, 2, pt. 1, 89, pl. 27, figs. 1–7 (1865): Foerste, Jour. Sci. Lab. Denison Univ., 21, 377, pl. 39, figs. 2 A-D (1926).

Conchs trochoceroid in their method of coiling, but the apical end is not sufficiently out of the plane of symmetry of the remainder of the conch to place it outside of the plane formed by the nearest side of the last volution. The coiling is almost gyro-

ceraconic, there being no actual contact between adjacent parts of successive volutions. The ventral and lateral sides are slightly flattened, resulting in a slightly quadrangular cross-section. The sutures of the septa curve distinctly downward laterally, but ventrally and dorsally their course is almost directly transverse. The siphuncle is close to the ventral wall of the conch, but not in actual contact. Its segments are fusiform, narrowing downward. The septal necks are short, and their lower margins curve distinctly outward. The surface of the shell is not annulated, but, at one or two levels along the living chamber of mature specimens, it is supplied on each of the two lateral sides with a short horizontal wing which locates the position at which during earlier stages of growth the former margin of the aperture flared out laterally. These lateral wings are supposed to have been similar to those of the species described by Barrande under *Gyroceras alatum* (Barrande, *loc. cit.*, pl. 44), but later used by Hyatt as the genotype of *Ptenoceras*. Typical *Trochoceras* differs from *Ptenoceras* chiefly in its quadratic cross-section; moreover, the location of its apical end is out of the plane of symmetry of the remainder of the conch, instead of in the plane of symmetry, as in *Ptenoceras*.

Neither *Trochoceras* nor *Ptenoceras* are known in American strata. Both are confined to the Lower Devonian of the Bohemian part of Czechoslovakia.

LECHRITROCHOCERAS Foerste

Genotype: *Trochoceras desplainense* Hall, 20th Rep. New York State Cab. Nat. Hist., 359, pl. 16, figs. 8–10 (1868); *Lechritrochoceras desplainense* Foerste, Jour. Sci. Lab. Denison Univ., 21, 367, pl. 35, figs. 5 A, B (1926).

Trochoceroids with circular or slightly depressed cross-sections, the apical end being shifted laterally from the plane of symmetry, but not beyond the plane bounding the adjacent lateral side of the last volution of the conch. Adjacent parts of volutions are in contact with each other, except along the upper part of the living chamber which is free. There is a shallow impressed zone where the apical part of the conch is in contact with one of the

dorso-lateral shoulders of the last volution. The direction of coiling usually is dextral. The surface of the shell is crossed by rib-like annulations which are distinct ventrally as well as laterally. In addition, the genotype is ornamented by numerous transverse striae which are parallel to the oblique annulations. The location of the siphuncle is central.

At present, the transverse striae, in the absence of longitudinal striae, are known among American species only in the genotype, *Lechritrochoceras desplainense*. It is not certain whether the species described by Hall under the names *Trochoceras bannisteri*, *Trochoceras costatum*, *Trochoceras notum*, and *Cyrtoceras rigidum* are similarly striated, but this is assumed to be the case, and hence the latter also are referred provisionally to *Lechritrochoceras*.

28. **Lechritrochoceras desplainense** (McChesney)

Plate VIII, figs. 1 A, B

Trochoceras desplainense Hall, 20th Rep. New York State Cab. Nat. Hist., 359, pl. 16, figs. 8–10 (1868). *Lechritrochoceras desplainense* Foerste, Jour. Sci. Lab. Denison Univ., 21, 367, pl. 35, figs. 5 A, B (1926).

The specimen figured by Hall (plate VIII, figs. 1 A, B) consists of two fragments of the same specimen. The larger of these includes chiefly a cast of one of the lateral sides of the trochoceroid conch; namely, that side which exposes the more apical parts of the conch best. The other fragment, which fits snugly into the cast of the exterior, is a cast of the interior of the living chamber and of the adjoining three camerae. Hall's figure 8, cited above, is a restoration, based chiefly on a wax impression of the first fragment, with such additional details of the upper part of the living chamber as are presented by the second specimen.

The complete specimen included slightly more than 2 volutions. The living chamber is free from the adjacent part of the preceding volution for a length of 15 mm. The remainder of the conch has a maximum diameter of 55 mm. across the umbilical opening. This opening is almost circular, and about 8 mm. in diameter. At successive half volutions the dorso-ventral diameter

of this conch enlarges from 3.5 mm. to 8 mm., 14 mm. and 23 mm., the corresponding diameter at the aperture being 28 mm. At the base of the living chamber, where the dorso-ventral diameter is 24 mm., the lateral diameter is 23 mm., measuring in each case to the crests of the transverse ribs. The 3 camerae adjoining to the base of the living chamber occupy a total length of 18 mm. when measured along their ventral outline. From this it is estimated that originally about 4 camerae occupied a length equal to the dorso-ventral diameter of the conch. The sutures of the septa curve moderately downward laterally, rising distinctly in a ventrad direction. The concavity of the septum at the base of the group of 3 camerae equals 4 mm. beneath the lowest part of its suture. The location of the siphuncle is central, and its diameter at its passage through the septum just mentioned is 1.5 mm. in diameter. The surface of the shell is ornamented by strong transverse ribs which curve downward strongly in a ventrad direction along their entire course, though this curvature increases on approaching the ventral side of the conch. Their total downward curvature exceeds slightly the height of 4 camerae. Along the ventral side of the conch they indicate the successive stages of location of the former deep but broad hyponomic sinus. These transverse ribs or annulations are low but distinct dorsally, but grow in elevation along the lateral sides of the conch, and become bold ventrally. Along the living chamber and the adjacent part of the phragmacone nearly 4 ribs occur in a length equal to the dorso-ventral diameter, when counted along the ventral outline. When the living chamber is held so that its dorsal side faces the observer, the impressed zone, along the line of contact with the preceding volution, is on the left of the median dorso-ventral plane passing through this part of the conch. The curvature of the very low spire of this conch is dextral. The line of contact included almost the entire length of the shell, from the point of contact of its apical end with the following volution to within 15 mm. of the aperture. The surface of the shell in its present state of preservation is smooth, with a few extremely vague and far separated indications of transverse lines parallel to the ribs.

Occurrence.—Racine, Wisconsin; in the Racine dolomite. No. 2126, American Museum of Natural History. Associated with this specimen, in the same fragment of rock as that retaining the impression of the exterior of the conch, is the holotype of the species described by Hall as *Cyrtoceras brevicorne*.

29. **Lechritrochoceras telleri** Sp. nov.

Plate VII, figs. 2 A, B; plate XXV, fig. 16

Specimen consisting of most of a living chamber, 50 mm. of its length being preserved, but the marginal part of its aperture being missing. The ventral outline of this chamber has a radius of convex curvature of 37 mm. The dorso-ventral diameter enlarges from 17 mm. at its base to 20 mm. at its top. At the base of the specimen the lateral diameter equals the dorso-ventral one, but at its top this lateral diameter is 1 mm. less than the dorso-ventral one. The suture of the septum at the base of this chamber curves downward laterally 2 mm. The concavity of the septum is 3 mm. below the lowest part of its suture laterally. The center of the siphuncle is located 5 mm. from the ventral side of the conch, where its dorso-ventral diameter is 17 mm. The number of transverse annulations in a length equal to the dorso-ventral diameter equals 3. These annulations curve strongly downward from the dorsal toward the ventral side of the conch. They are relatively faint dorsally and dorso-laterally, but become more distinct ventro-laterally, and are most prominent ventrally. Compared with *Lechritrochoceras desplainense*, the annulations are equally prominent, but they are more distant from each other, and the conch enlarges at a slower rate. There is no trace of a dorsal impressed zone.

Occurrence.—Chicago, Illinois; in the Racine. In the Teller collection of the U. S. National Museum; holotype. Plate VII, figs. 2 A, B.

Named in memory of Edgar E. Teller.

Racine specimen.—A fragment of a living chamber (plate XXV, fig. 16), about 40 mm. long parallel to its curving central axis, is similar to the preceding specimen in the prominence and

relative distance between the annulations, but differs in curving more rapidly, and in having the intervals between the annulations slightly shorter. When viewed from its dorsal side, the distinct impressed zone is on the left of the dorso-ventral plane passing through the median part of the chamber, so that its trochoceroid coiling evidently is dextral. Racine, Wisconsin; in the Racine. No. 2127–1, in the American Museum of Natural History, where it is incorrectly labelled *Trochoceras costatum*, the annulations of the latter being much more closely crowded.

2. LECHRITROCHOCERAS COSTATUM (HALL)

Clay impression of natural cast of exterior of shell, modelled to show probable rate of expansion of conch.

30. **Lechritrochoceras costatum** (Hall)

Text figure 2

Trochoceras costatum Hall, 20th Rep. New York State Cab. Nat. Hist., rev. ed., 402, pl. 25, fig. 15 (1870). Not figs. 1, 2 on pl. 16 of the 1868 edition, which represents *Trochoceras notum* Hall.

The type consists of a natural impression of the left side of the

conch, if the latter be held with the ventral part of the living chamber facing away from the observer, and the aperture facing upward. This impression includes a length of one and a half volutions, but the apical part is missing and the living chamber may have been a little longer; however, it is not probable that the original length of the conch exceeded two volutions. When the conch is oriented as indicated above, the apical end of the conch curves toward the left side of the living chamber, so that this left side becomes the apical end of the extremely low spire, and, if this spire be viewed from above, the direction of its enlargement is dextral, and not sinistral as stated by Hall. In this respect, therefore, it conforms with other species of trochoceroids described so far from American sources. The amount of deviation of the apical end of the conch from the dorso-ventral plane of symmetry passing through the median part of the last volution is slight. At no point is the impression produced by the conch deep enough to retain both its dorsal and its ventral outline. However, the length of the dorso-ventral diameter may be at least estimated at several points along four-fifths of that part of the conch beginning with the smaller end preserved. At this smaller end, the dorso-ventral diameter is 4.5 mm. At a distance of four-fifths of a volution or 90 mm. from the smaller end of the specimen, measured along its ventral outline, this dorso-ventral diameter is 17 mm. If this rate of enlargement continued as far as the top of the living chamber, the dorso-ventral diameter near its aperture would be approximately 35 mm., which is much larger than that presented by Hall's figure, whose published figure gives no indication of the absence of any definite ventral outline in the type itself. Even if the rate of enlargement of the conch diminished at later stages of growth it is very unlikely that it became as small as indicated by Hall's figure. Nothing is known of the lateral diameter of any part of this type, nor is there any trace of the septa. That the larger end of the specimen belongs to the upper part of the living chamber is indicated by the gerontic characters assumed here by the transverse ribs or annulations. These become much less prominent and more irregularly spaced, with a few, very obscure indications of transverse lines, parallel

to the annulations. The draughtsman, R. P. Whitfield, evidently made a conscientious attempt to restore the specimen correctly, and the annulations in the figure published by Hall are well spaced; however, there is no indication in the type of the sigmoid curvature of these annulations on approaching the ventral outline of the conch as shown in the figure. Such change of direction as might have existed probably were confined to the vicinity of this median outline, and would scarcely be readily perceptible in a directly lateral view. Compared with *Lechritrochoceras desplainense* and *Lechritrochoceras telleri*, the annulations are relatively more numerous, but almost as prominent. The smaller end of the conch was in contact with the upper part of the phragmacone. Apparently it was free from the living chamber for the greater part of the length of the latter, but the rate of separation was so slight that apparently the upper part of this chamber probably was only 3 mm. or less distant from the nearest part of the preceding volution.

Occurrence.—Racine, Wisconsin; in the Racine. No. 2127–1, in the American Museum of Natural History; holotype.

31. **Lechritrochoceras notum** (Hall)

Plate XXV, fig. 14; plate VII, figs. 9 A, B; plate VIII, figs. 4 A, B

Trochoceras notum Hall, 20th Rep. New York State Cab. Nat. Hist., 360, pl. 16, figs. 1, 2 (1868). Figures incorrectly cited as *Trochoceras costatum* on explanation of plate 16, but corrected to *Trochoceras notum* in the *Errata* facing page 410. See also revised edition, 403, pl. 16, figs. 1, 2, (1870). *Lechritrochoceras notum* Foerste, Jour. Sci. Lab. Denison Univ., 23, 219, pl. 40, figs. 8 A, B (1928).

The type consists of the lower part of a living chamber which had a length of at least 30 mm. along its ventral outline, its total length undoubtedly being considerably greater. Its ventral outline has a radius of convex curvature of 21 mm. At the base of the chamber its dorso-ventral diameter is 14 mm. and its lateral diameter is estimated at 17 mm. This dorso-ventral depression

of the conch is its chief characteristic. The dorso-ventral diameter enlarges from 14 mm. to 17 mm. within a length of 25 mm., measured along the ventral outline of the chamber. The suture of the septum at its base is almost straight, and slopes downward in a ventrad direction. The concavity of this septum is 4 mm. The location of the siphuncle is central. About 5 oblique annulations occur in a length equal to the dorso-ventral diameter at the top of the series counted, if counted along the ventral outline. These annulations slope downward from the dorsal side of the conch as far as its ventro-lateral parts and then slope increasingly downward as far as the median part of its ventral side, where there is a slight tendency toward angulation in their curvature. If the living chamber be oriented with its dorsal side facing the observer, and with its top facing upward, then the dorsal impressed zone is distinctly on the left of the dorso-ventral plane passing through the central axis of the chamber. Moreover, this impressed zone is inclined so as to be nearer the left side of the chamber at its base than farther up. This indicates that the trochoceroid conch enlarged in a dextral direction.

Occurrence.—Bridgeport, in the southern part of Chicago, Illinois; in the Racine. No. 2127–2, American Museum of Natural History; holotype. Plate XXV, fig. 14.

A more complete specimen from the same locality exposes the cast of the interior of the living chamber and also the impression of the exterior of the phragmacone. Five annulations on the living chamber occupy a length equal to the dorso-ventral diameter of the conch. These annulations curve strongly backward on the ventral side of the conch. They are less prominent ventrally than laterally. The dorso-ventral diameter enlarges from 3 mm. at the apical end of the specimen to 11.5 mm. at the base of the living chamber, one volution distant from the former. Along the living chamber it enlarges from 11.5 mm. to 15 mm. in a length of 30 mm. measured ventrally. The siphuncle is slightly ventrad of the center of the conch, its passage through the septum at the base of the living chamber being half a millimeter in diameter. The living chamber is in contact with the apical part

of the phragmacone along its entire length, and the line of contact is so near its median line that it is impossible to determine with confidence whether the direction of spiral growth of the conch is dextral or sinistral, though it appears to be dextral, as in *Lechritrochoceras desplainense*. The lateral diameter of the living chamber is about 1 mm. greater than the dorso-ventral one. On the cast of the exterior of the phragmacone there are distinct traces of narrow striations parallel to the annulations, and near the apical end of the conch there also are traces of less distinct and more distant longitudinal striae. Only one suture is preserved, and this curves downward ventrally, and is crossed diagonally by three annulations.

Occurrence.—Bridgeport, in the southern part of Chicago, Illinois; in the Racine. No. 2162, Illinois State Museum of Natural History. Plate VII, figs. 9 A, B.

A living chamber found at Hawthorne (plate VIII, figs. 4 A, B), west of Chicago, is referred to the same species. In the collection of the writer.

Remarks.—*Lechritrochoceras notum* differs from *Lechritrochoceras rigidum* chiefly in being more strongly curved lengthwise, so that its outer volution is much smaller. The number of annulations is about the same, but these annulations curve more strongly backward ventrally. The living chamber apparently was shorter.

32. **Lechritrochoceras bannisteri** (Winchell and Marcy)

Plate VII, figs. 6, 7

Gyroceras bannisteri Winchell and Marcy, Mem. Boston Soc. Nat. Hist., 1, 102 (1865). *Trochoceras* (*Gyroceras*) *bannisteri* Hall, 20th Rep. New York State Cab. Nat. Hist., 403, pl. 25, fig. 17 (1870).

The following is the original description by Winchell and Marcy, altered however so as to replace the term dorsal with the word ventral, and the term ventral by dorsal, so as to conform with present usage of these words. Moreover, the measurements originally given in fractions of an inch are here translated into millimeters. This specimen was found at Bridgeport in the southern part of Chicago; in the Racine.

Shell consisting of about one and a half whorls, barely in contact, gradually increasing in diameter; transverse section nearly circular; surface ornamented by encircling ridges which extend quite around the shell, crossing the dorsal side at right angles, thence arching back to the ventral side, where the corresponding branches meet in a broadly rounded angle of about 100°. The distance from the summit of one ridge to that of the next, measured on the venter, varies from one third the transverse diameter of the whorl, to considerably less. The space between the ridges is nearly flat, and in the cast—but not on the shell—discloses indications of two low, barely perceptible ridges. The last chamber seems to be entirely destitute of surface ornaments, except incremental lines, which are sinuate ventrally, to correspond with the ridges. There are indications that the aperture was correspondingly sinuate. The position of the siphon has not been observed, but a feeble depressed line or shallow furrow runs along the ventral side of the cast, visible between the ridges, and creating a suspicion (incorrect) that the siphon is in close proximity. Dorso-ventral diameter, 19.8 mm. at a place where the transverse diameter is 18.5 mm.; distance between the ridges on the venter, at the same place, 6.35 mm. In other specimens the ridges are more approximated. This species differs from *Gyroceras* (*Lituites*) *americanum* Billings, in not being flattened on the venter, and in the course of the annulations. It differs from *Lituites giganteus* Sowerby, in having the annulations extend quite across the venter without diminution in size.

It should be noted in the preceding description that probably two distinct species here are included. Almost the entire description is based on a single specimen in which the distance between the transverse ridges was one-third of the dorso-ventral diameter of the conch, when measured along its ventral outline at a point where this diameter was 19.8 mm. However, at two places in this description there is reference to specimens in which the distance between the ribs is considerably less, or in which these ridges are described as more approximated. It is evident that it is one of the latter specimens of which Prof. Winchell sent a gutta-percha cast to Hall, and which Hall described and figured in his revised edition of the 20th Report of the New York State Cab. Nat. Hist., in 1870. Since the specimen with the more distant transverse ribs is missing, and that figured by Hall was sent to him under the name *Gyroceras bannisteri*, and since the latter is the only one figured, it may be regarded as the lectotype. Unfortunately the location of this lectotype also is unknown.

Topotype.—The topotype, as figured by Hall, consisted of a rapidly enlarging conch in which the apical end never came in contact with the following volution. At the larger end of the

specimen about 6.5 transverse ribs occur in a length equal to the dorso-ventral diameter, when counted along its ventral outline. The larger end of the specimen curves away from its apical end, indicating that even in a conch in which the succeeding volution came in contact with its apical end, most, if not all, of the living chamber would be free. In these particulars the specimen figured by Hall as *Trochoceras bannisteri* differs from *Trochoceras notum*, the living chamber of the latter being in contact with the preceding volution along most, if not all, of its length, and the transverse ribs being a little less numerous. Hall stated that he figured the umbilical side of the conch, its enlargement being in a dextral direction when viewed from the opposite side. Bridgeport, in southern Chicago, Illinois. The present location of this specimen is unknown.

University of Chicago specimens.—One specimen, numbered 18097-A (plate VII, fig. 6), is similar in size and ornamentation to the specimen figured by Hall, but its apical end is in direct contact with the succeeding volution for a short distance. The transverse annulations are distinct along the entire length of the phragmacone, and indistinct along the cast of the interior of the living chamber, but they may have been distinct on the exterior of the shell of the latter. The living chamber is 30 mm. long, and the cross-section at its base is circular, being 13 mm. in diameter. The center of the siphuncle is 5 mm. from the ventral wall of the conch. The curvature of this conch is dextral. In a second specimen from the same locality, Bridgeport, numbered 18097-B, only the cast of the interior of the living chamber is present. In both specimens the transverse ribs are most distinct ventrolaterally and are almost obsolete ventrally.

In another specimen, numbered 22940 (plate VII, fig. 7) in Walker Museum, University of Chicago, the conch attains a dorso-ventral diameter of 15 mm. It enlarges even more rapidly than the Bridgeport specimens, but its umbilical opening is similar in size, and its transverse ribs are equally numerous.

Chief specimen described by Winchell and Marcy.—This specimen was characterized by the distance between the transverse ribs equalling about one third of the dorso-ventral diameter, when

measured along the ventral outline. This evidently is more numerous than in the type of *Lechritrochoceras telleri*. It is more numerous also than in the case of the Racine specimen here referred to the same species. However, in neither of these specimens do the transverse ribs practically disappear along the living chamber, being replaced only by lines of growth. Hence, provisionally, they are regarded as distinct.

33. **Lechritrochoceras rigidum** (Hall)

Plate VII, figs. 5 A, B

Cyrtoceras rigidum Hall, 20th Rep. New York State Cab. Nat Hist., 358, pl. 16, figs. 3, 4, 5, but not text figure (1868).

Conch represented by two fragments which fit snugly together for a length of more than 30 mm. along the dorso-ventral side of that part figured by Hall. The latter consists chiefly of the living chamber, but at its base the dorsal side of two camerae are in evidence. The living chamber apparently is 50 mm. long when measured along its ventral outline. The radius of convex curvature of this ventral outline is 30 mm. The apicad continuation of this outline indicates an umbilical opening about 23 mm. in diameter. A trace of the conch on the opposite side of this opening from the basal part of the living chamber retains parts of several camerae distinctly. Therefore, Hall's text-figure illustrating the rate of coiling of the conch is no longer tenable. On the contrary, if the rate of tapering of the conch in an apicad direction continued at the same rate at its smaller end as along the living chamber then its apical end should either have touched the dorsal side of the living chamber a little below mid-height, or should almost have come in contact with the latter. Apparently the latter was the case, since the dorsal side of the living chamber does not show a distinct impressed zone; on the contrary, the transverse ribs are distinct along the upper half and lower quarter of the length of the living chamber. The direction of enlargement of the conch was in a dextral direction, its apical end approaching the left side of the living chamber when the latter is so oriented as to have its dorsal side face the observer, its aperture being directed upward.

The conch is slightly compressed laterally toward the aperture. At its aperture its dorso-ventral diameter is 19.5 mm. and its lateral one is 18.5 mm. At the base of this chamber, the interval being 50 mm., the dorso-ventral diameter is 13 mm. and the lateral one is almost the same. The sutures of the septa appear to be nearly straight. The septa are strongly concave. The siphuncle is small and slightly ventrad of the center of the conch. The annulations are rather prominent, 5.5 occurring in a length equal to the dorso-ventral diameter at various points along the living chamber. These annulations slope strongly downward in a ventrad direction from the dorsal side as far as the ventro-lateral parts of the conch, increasing their rate of slope slightly along the remaining distance to the ventral outline.

Occurrence.—Bridgeport, in the southern part of Chicago, Illinois; in the Racine. No. 2121, American Museum of Natural History; holotype.

34. **Lechritrochoceras lentidilatatum** Sp. nov.

Plate XXV, figs. 1, 2, 3

Conch similar to *Lechritrochoceras notum* in its size and method of coiling, the living chamber being free from the preceding volution only near the aperture. It differs chiefly in the smaller number of its transverse ribs, about 3.5 ribs occurring in a length equal to the dorso-ventral diameter, when counted along the ventral outline. In one specimen the maximum diameter across the umbilical opening is 42 mm., the coiling of the conch is dextral. In another specimen two and a half volutions were present. Of these, one and a half volutions are represented by the living chamber and the upper part of the phragmacone, and the additional volution, forming the smaller end of the phragmacone, is indicated by the impression left along the contact zone following the dorso-lateral shoulder of the conch. The living chamber is 43 mm. long on its ventral outline. The sutures of the septa are almost straight and directly transverse to the curving central axis of the conch, rising slightly in a ventrad direction on approaching the living chamber. In the collection of Dr. L. D. Welch, deposited in Wilmington College. Cotype. Plate XXV, fig. 2.

A similar specimen, in the collection of Dr. G. M. Austin in the U. S. National Museum, consists of the living chamber, 6 camerae, and outline left by the half volution immediately adjacent to the latter. Cotype. Plate XXV, fig. 1.

Occurrence.—Moodie quarry, in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite.

Cedarville specimen.—A fragment of a living chamber, found at Cedarville, Ohio, shows the tendency toward angularity of the transverse ribs or annulations along the median part of the ventral side of the conch. The siphuncle is small and is located a short distance ventrad of the center of the conch. Plate XXV, fig. 3.

Remarks.—The conch is slightly depressed dorso-ventrally, the ratio of its dorso-ventral diameter to the lateral one varying from 83 to 86 per cent in different specimens. The last transverse rib, just before reaching the aperture, tends to become less prominent or partially obsolete.

35. **Lechritrochoceras waldronense** (Hall)

Plate XXV, figs. 15 A, B

Trochoceras waldronense Hall, 28th Rep. New York State Mus. Nat. Hist., 179, pl. 27, figs. 13–15 (1879); Ann. Rep. Indiana Dep. Nat. Hist., 326, pl. 28, figs. 13–15 (1882).

The specimen used by Hall for his figures 13 and 14 cited above is selected here as a holotype. This specimen (plate XXV, fig. 15 A) has a maximum diameter across the umbilical opening of 39 mm. Its direction of enlargement is dextral, the apical part of the conch being nearer the left side of the conch when the living chamber of the latter is oriented so that its ventral side faces away from the observer and its aperture faces upward. Its umbilical opening was small, apparently not exceeding 2.5 mm. in the shorter diameter. The length of the living chamber along its ventral outline is 39 mm. In this length its dorso-ventral diameter enlarges from 10.5 mm. at its base to 17 mm. at the aperture. The corresponding lateral diameters, in the present condition of the specimen, are 9 mm. and 12.5 mm. A part of this lateral compression probably is due to pressure exerted by the

weight of overlying sediments after the death of the animal, but the exact form of cross-section of the conch can not be determined since all specimens found so far show about the same degree of compression. The septum at the base of the chamber is the only one whose location can be determined with certainty. Nothing is known of the location of the siphuncle. The transverse ribs are nearly straight between the dorsal side of the conch and its ventro-lateral parts, but they slope strongly downward in a ventrad direction, this slope increasing beyond the ventro-lateral parts, toward the ventral outline. The result of the lateral compression of the conch has been to accentuate the narrowness of the downward curvature of these ribs ventrally and increase their angularity along the median part of this ventral side. These ribs are preserved only along the living chamber. In the holotype 7.5 of these ribs occur in a length equal to the dorso-ventral diameter of the conch at the top of the series counted. Along the upper half of the chamber, for a length of about 28 mm., the transverse ribs become inconspicuous or locally obsolete. At the aperture their place appears to be taken by transverse striae, more closely placed than the ribs. Moreover, at the aperture these striae slope and curve less strongly downward, the hyponomic sinus here evidently being more shallow than at earlier stages of growth.

In the original of Hall's figure 15, the number of transverse ribs in a length equal to the dorso-ventral diameter is 8.5. These ribs rapidly become faint along the upper half of the living chamber, for a length of 20 mm. Plate XXV, fig. 15 B.

Occurrence.—Waldron, Indiana; in the Waldron shale member of the Niagaran. No. 1956, American Museum of Natural History; cotypes.

36. **Lechritrochoceras** (?) **cinctutum** (Foerste)

Plate XXV, fig. 7

Cyrtoceras cinctutum Foerste, Jour. Sci. Lab. Denison Univ., 14, 61, pl. 3, figs. 37 a, b (1909).

The holotype includes about three-fourths of a volution. The living chamber is 30 mm. long, when measured along its ventral

outline. The dorso-ventral diameter increases from 6.5 mm. near the base of the specimen to 13 mm. at the base of the living chamber, and to 17.5 mm. at the aperture, the intervals being 40 mm. and 30 mm. The corresponding lateral diameters are 5.5 mm., 10 mm. and 14 mm. Judging from the amount of curvature of the apical part of the specimen and its rate of tapering it is possible that the apical end of the conch touched the living chamber somewhere near mid-height of the dorsal outline of the living chamber. However, the transverse ribs on the dorsal side of the living chamber are uninterrupted in their course, as though actual contact between the apical end of the conch and its living chamber had not been established. Moreover, there is no means of determining whether the coiling was trochoceroid or not. Along the lower part of the phragmacone about 3 camerae occur in a length equal to the dorso-ventral diameter, changing to 2.5 camerae in a corresponding length farther up. The sutures of the septa curve only slightly downward laterally, and are almost directly transverse to the curving central axis of the conch. The siphuncle is small; it is ventrad of the center of the conch, its distance from the ventral wall being three-tenths of the dorso-ventral diameter of the conch. Along the ventral outline of the living chamber 5 transverse ribs occur in a length equal to this dorso-ventral diameter. These ribs are distinct dorsally and are most conspicuous ventro-laterally, though also distinct along the median part of the ventral side. They curve downward moderately along the dorsal third of the conch, and then with increasing rapidity as far as the median part of its ventral side, where they tend to be somewhat angulate. The surface of the shell is transversely striated, and there is a possibility of longitudinal striae. At least, fine longitudinal striae are present on a cast of the interior of a living chamber. The transverse striae are parallel to the ribs.

Occurrence.—Clifton, on the Tennessee river, in western Tennessee; in the Osgood member of the Niagaran. Specimen in the collection of the writer; holotype.

Remarks.—This species is regarded as an early stage in a line of development which finally led to typical *Lechritrochoceras* as

found in the Racine. Better preserved specimens are needed to confirm this opinion. In the case of the species here described as *Lechritrochoceras waldronense,* its structure is closely similar to that of *Lechritrochoceras notum* and *Lechritrochoceras bannisteri.*

LEUROTROCHOCERAS Foerste

Genotype: *Trochoceras aeneas* Hall, 20th Rep. New York State Cab. Nat. Hist., pl. 25, fig. 16, foot-note (1870); *Leurotrochoceras aeneas* Foerste, Jour. Sci. Lab. Denison Univ., 21, 373, pl. 43, figs. 6 A, B (1926).

Conchs apparently closely similar to those of *Lechritrochoceras,* and differing from the latter chiefly in their flattened sides. The dorso-ventral diameter is distinctly longer than the lateral one. The transverse annulations or ribs usually are distinctly defined ventrally but become much weaker or even obsolete laterally, at least on casts of the interior of the conch. Nothing is known of the surface of the shell beyond the fact that it is annulated.

37. **Leurotrochoceras aeneas** (Hall)

Plate VII, figs. 1 A, B

Trochoceras aeneas Hall, 20th Rep. New York State Cab. Nat. Hist., pl. 25, fig. 16, and foot-note (1870): *Leurotrochoceras aeneas* Foerste, Jour. Sci. Lab. Denison Univ., 21, 373, pl. 43, figs. 6 A, B (1926).

Conch consisting of the phragmacone with the basal and dorsal part of the living chamber. The apical end of the conch is only faintly asymmetrical in location, the coiling being more nearly gyroceroid rather than trochoceroid. The coiling is sinistral. The conch enlarges dorso-ventrally from 4.5 mm. at its apical end to 19 mm. at the base of the living chamber, the lateral diameter at the latter being estimated at 13 or 14 mm., only one of the lateral sides being preserved here. The cross-section of the conch is strongly flattened laterally, especially toward the upper part of the phragmacone and along the living chamber. The ventral side is more narrowly rounded than the dorsal one. The number of camerae in a length equal to the dorso-ventral diame-

ter is 5 when counted along the ventral outline. The conch is crossed by strongly oblique annulations which are obsolete dorsally, become visible dorso-laterally, and are most prominent ventrally. They curve increasingly downward ventrally, indicating former locations of the hyponomic sinus, at a time when its depth equalled the height of 3 camerae.

Occurrence.—Lyons, Iowa; in the Upper Niagaran. No. 2129, American Museum of Natural History; holotype.

38. **Leurotrochoceras compressum** Sp. nov.

Plate VI, figs. 3 A, B, C; pl. VII, figs. 4 A, B

Living chamber about 38 mm. long, its aperture not being retained. It enlarges dorso-ventrally from a diameter of 21 mm. at its base to 25.5 mm. at a point 15 mm. farther up. The corresponding lateral diameters are 13 mm. and 17 mm. The chamber is flattened laterally, and the ventral part of its cross-section is more narrowly rounded than its dorsal part. There is a dorsal impressed zone which is only slightly out of the plane of symmetry of the chamber. The direction of coiling is dextral. The suture at its base curves downward laterally about 5 mm. The siphuncle is located about 2 mm. ventrad of the centre of the conch. The specimen is a cast of the interior of the chamber, and its surface is smooth. No. 81428, U. S. National Museum; holotype. Plate VI, figs. A, B, C.

Associated in the same strata was found a fragment of a phragmacone which is equally flattened, but which may not belong to the same species. The sutures of the septa curve downward in a similar manner and the lateral sides are equally smooth, but the ventral side is distinctly marked by transverse ridges which curve strongly downward, and which evidently represent the annulations of other species of the genus. The number of camerae in a length equal to the dorso-ventral diameter is about 4. No. 81428 a, U. S. National Museum. Plate VI, figs. 4 A, B.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

39. **Leurotrochoceras paucoplanatum** Sp. nov.

Plate VII, figs. 3 A, B; 8 A, B

Species represented by two small, but distinctive, fragments of the phragmacone. Judging from the location of the impressed zone on the dorsal side of these fragments, the lengthwise curvature of the conch was dextral. The cross-section is compressed laterally, the dorso-ventral diameter being 17 or 18 mm. where the lateral diameter is 15 or 16 mm., according as these measurements are made on the crests of the annulations or in the intermediate grooves. The lateral diameter is greatest at the dorso-lateral shoulders, the lateral sides being somewhat flattened and converging ventrally, so that the ventral side is more narrowly rounded than the dorsal one. About 5 camerae occur in a length equal to the dorso-ventral diameter of the conch, when counted along the ventral outline of the larger specimen (plate VII, figs. 3 A, B). About 4 camerae occur in a corresponding length in the smaller one (Plate VII, figs. 8 A, B). The sutures of the septa curve strongly downward laterally, for a distance of 4 mm. in case of the larger specimen. The septum at the base of this specimen curves a little more than 1 mm. farther down at its middle than laterally. The center of the siphuncle is 6.5 mm. from the ventral wall of the conch. The surface of the cast of the interior of the conch is crossed by annulations which curve strongly downward from the dorsal toward the ventral side of the conch. These annulations are less numerous than the camerae but their exact relative number is unknown. They are prominent ventrally, become less prominent laterally, and apparently disappear dorsally.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81485 in the U. S. National Museum; holotype; also no. 81485-a, in the same Museum.

Remarks.—In its general appearance, including the relative distance between the transverse ribs, this species closely resembles *Lechritrochoceras telleri;* however, in *Leurotrochoceras paucoplanatum* the transverse ribs disappear along the dorsal half of the lateral sides, the latter being distinctly flattened.

40. "Nautilus" wilmingtonense Sp. nov.

Plate VII, fig. 10

This is not a genuine species of *Nautilus*, but nothing is known of the location of the siphuncle, and the indentation of the upper half of the dorsal side of the living chamber by the apical end of the conch probably is abnormal, so that it does not appear advisable to propose for it a new generic name until more is known of the normal structure of the conch.

The specimen, in its present state, consists of a single volution. Evidently the original apical part of the conch is missing, and the lowest camera remaining belongs some distance above its original apical end. The phragmacone occupies slightly more than half of the length of the volution. Within this distance the dorso-ventral diameter enlarges from 7 to 10 mm., increasing to 12 mm. at mid-height of the living chamber. Cross-sections of the phragmacone are approximately circular, probably with the lateral diameter slightly greater than the dorso-ventral one. The length of the living chamber, measured along its ventral outline, is 25 mm. Beneath its aperture, the walls of the chamber are slightly constricted, and then diverge slightly, both the constriction and the expansion of the aperture being almost imperceptible. At its contact with the smaller end of the phragmacone, the dorsal wall of the chamber closely fits against the basal septum. In consequence the aperture of this chamber has a somewhat reniform outline. The phragmacone has 9 distinctly defined camerae, and possibly also a tenth camera immediately beneath the living chamber, the presence of the latter being obscured by a break crossing the basal part of the living chamber. The sutures of the septa curve only slightly downward laterally. Nothing is known of the siphuncle, nor of the ornamentation of the surface of the shell.

Occurrence.—Moodie quarry, in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite. In the collection of Dr. L. D. Welch, deposited in Wilmington College; holotype.

SACTOCERAS Hyatt

Genotype: *Orthoceras richteri* Barrande, Systeme Silurien du Centre de la Boheme, 2, text 3, 570, pls. 318, 322, 323, 349 (1874); Foerste, Jour. Sci. Lab. Denison Univ., 20, 227 (1924).

Relatively long orthocones with siphuncles of moderate size, the segments approximately globular, varying from slightly depressed to slightly elongated in a vertical direction. The septal necks are short and their lower margins curve outward in a cyrtochoanitic manner. In the interior of the siphuncle the septal necks are enveloped by calcareous deposits which form interior annulations. In vertical sections these appear to have a concentric structure, but in horizontal sections there is no radiate structure. With increasing age these annular deposits encroach on the interior of the siphuncle. The sutures of the septa are directly transverse.

In typical *Loxoceras* McCoy, on the contrary, the calcareous deposits within the siphuncle have a radiate structure as in the *Actinosiphonata*, and the sutures of the septa are sinuously curved, descending from the dorsal toward the ventral side of the conch.

41. **Sactoceras depressum** Sp. nov.

Plate VIII, figs. 5 A, B; 6 A, B; 7 A, B

Specimen with a lateral diameter of 25 mm. and a dorso-ventral one of 21 mm. at its base, the center of the siphuncle being 7 mm. from that side of the conch toward which the septa rise, here called the ventral side. A single segment of the siphuncle remains at its base, its diameter being 5 mm. and its height slightly less than 4 mm. Being located on the rising slope of the septum, its lateral view presents an oblique outline, which is distinctly depressed vertically. No. 81429, U. S. National Museum; holotype; plate VIII, figs. 6 A, B. A second specimen, numbered 81429 a, has a lateral diameter of 27 mm. and a dorso-ventral one of 24 mm. The center of the siphuncle is 8 mm. from that side toward which the suture rises. The nummuloidal segment of the siphuncle at the base of the specimen is 4 mm. in diameter, and the septal neck at its base has a diameter of 2.5 mm. The upper-

most camera is distinctly shorter than the rest, indicating that the conch was mature.

One of the specimens in the Savage collection (No. 199–A; plate VIII, figs. 5 A, B) consists of 7 camerae and the basal part of the aperture. Lateral apical angle 3.5 degrees. Conch strongly depressed dorso-ventrally. At the base of the specimen its lateral diameter is 27 mm. and its dorso-ventral one is 23 mm. Seven camerae occur in a length equal to the lateral diameter. The sutures of the septa are straight but slope dorso-ventrally at an angle of 5 degrees with the horizontal. The siphuncle is a little nearer that side of the conch toward which the sutures rise. Another specimen, numbered 199-B (plate VIII, figs. 7 A, B), consists of a living chamber 42 mm. long, and of 2 camerae. At a level 43 mm. above the base of the chamber, measured along its lateral side, the cast of the interior of the chamber is slightly contracted, this contraction extending for 9 mm. upward, and the margin of the aperture may have been several millimeters farther up. Several low lines of growth slope obliquely downward in a direction opposite to that of the septa, at an angle of 15 degrees with a horizontal plane, thus indicating the ventral character of that side toward which the septa rise.

Some specimens have an apical angle of 7 degrees. One with a lateral diameter of 36 mm. has 9 camerae within a length equal to this diameter.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

AMPHICYRTOCERAS Foerste

Genotype: *Cyrtoceras orcas* Hall, Report of Superintendent of Geol. Surv. Wisconsin, 43 (1862); 20th Rep. New York State Cab. Nat. Hist., 350, pl. 17, figs. 1, 2 (1868); Foerste, Jour. Sci. Lab., Denison Univ., 20, 255, pl. 29, figs. 1 A, B, C; pl. 30, fig. 1 D (1924).

Conch subfusiform; convexly curved along its ventral outline; its dorsal outline concave along the greater part of the phragmacone, but convexly gibbous along the upper part of the phragmacone and the lower part of the living chamber, usually becoming slightly concave again toward the aperture. The cross-section

is depressed dorso-ventrally, the dorsal side usually being slightly flatter than the ventral one. The median part of the ventral margin of the aperture curves downward moderately, forming a relatively shallow hyponomic sinus. The sutures of the septa slope slightly downward ventrally in most species, though accentuated in others. The siphuncle is located close to the ventral wall of the conch. Its segments usually are elongated vertically, with only slightly convex or nearly straight lateral outlines, abruptly contracted at the septal necks.

42. **Amphicyrtoceras longidomum** Sp. nov.

Plate IX, figs. 1 A, B

Specimen consisting of a living chamber with 4 camerae still attached. Its greatest lateral diameter, at the base of the third camera beneath the living chamber, is 52 mm. From this point the conch contracts upward to a width of 49 mm. at the base of the living chamber and 38 mm. at the aperture. The maximum dorso-ventral diameter, at the base of the first camera beneath the living chamber, is 43 mm., contracting to 30 mm. at the aperture. The height of the living chamber is 52 mm. The transverse outlines of the conch are distinctly broader and flatter dorsally than ventrally, especially along the living chamber. Along the hyponomic sinus the upper part of the living chamber flares faintly outward for a distance of 1 mm. The sutures of the septa curve downward both dorsally and ventrally, but this curvature is greater on the ventral side. At the base of the specimen, where its dorso-ventral diameter is 38 mm., the diameter of the siphuncle is nearly 7 mm., and its center is 8 mm. from the ventral wall of the conch. No. 22898-A, Walker Museum, University of Chicago; holotype. Plate IX, figs. 1 A, B.

A second specimen, numbered 22892, consists of the base of the living chamber and 8 camerae. The uppermost camera is considerably shorter, indicating the maturity of the conch. The maximum dorso-ventral diameter, at the base of the second camera beneath the living chamber, is 36 mm., and this level appears also to be the point of greatest lateral expansion of the

conch. Below this point the ventral side of the conch flattens, so that the dorso-ventral diameter at the base of the specimen is only 30 mm. The corresponding lateral diameters are 46 mm. and 41 mm. Eight camerae occur in a length equal to the lateral diameter of the conch at the top of the series counted.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

Remarks.—The outward flaring of the shell along the hyponomic sinus is not a constant feature.

43. **Amphicyrtoceras savagei** Sp. nov.

Plate IX, figs. 3 A, B

Conch differing from typical *Amphicyrtoceras longidomum* in its more slender proportions and the more abrupt curvature of its ventral outline at the top of the phragmacone. The type is 91 mm. long, and includes the lower two-thirds of the living chamber and 12 camerae. Its greatest width, at the base of the second camera beneath the living chamber, is 41 mm., and from this point it contracts evenly downward to 31 mm. at its base. The corresponding dorso-ventral diameters are 34 mm. at the base of the first camera beneath the living chamber and 24 mm. at the base of the specimen. The transverse curvature of the conch is greatest at the maximum dorso-ventral diameter, becoming distinctly flatter farther down; 7.5 camerae occur in a length equal to the lateral diameter of the conch at the top of the series counted.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 211-A, in the Savage collection; holotype.

Named in honor of Thomas E. Savage.

44. **Amphicyrtoceras simulans** Sp. nov.

Plate X, figs. 1 A, B, C

Compared with *Amphicyrtoceras longidomum*, the living chamber is distinctly shorter, the dorso-ventral diameter at its base is greater, and the chamber contracts more rapidly in a dorso-ventral direction, the dorsal outline being distinctly concave at its

top. The type consists of a living chamber attaining its greatest diameters at its base, and contracting thence almost evenly until within 10 mm. of the aperture, where the dorsal outline is concave. At the base of this chamber its lateral outline is 57.5 mm. and its dorso-ventral one is 52 mm. The corresponding diameters at the aperture are 44 mm. and 36 mm. Toward the aperture the dorsal part of the cross-section is distinctly more flattened than the ventral one. The center of the siphuncle is 5 mm. from the ventral wall of the conch. The height of the chamber is 43 mm.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 212, in the Savage collection; holotype.

45. **Amphicyrtoceras subcentrale** Sp. nov.

Plate X, figs. 2, A, B, C

It is not known to what extent the location of the siphuncle varies in location in different individuals of the same species in *Amphicyrtoceras*, but *Amphicyrtoceras longidomum* is fairly common in the collections from Port Byron, and all the individuals identified so far have the siphuncle much nearer the ventral wall. The single living chamber here defined as *Amphicyrtoceras subcentrale* has the center of its siphuncle 16 mm. from the ventral wall of the conch where its dorso-ventral diameter is 40 mm., and its lateral one is 48 mm. In length this living chamber is similar to that of *Amphicyrtoceras longidomum*, but the upper part of its dorsal outline is more distinctly concave. To what extent this may prove a constant feature also is unknown.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 22898-B, Walker Museum, University of Chicago; holotype.

46. **Amphicyrtoceras occidentale** Sp. nov.

Plate XI, figs. 1 A, B; 4

Amphicyrtoceras occidentale is characterized by the inflated appearance of the lower half of the living chamber, contrasted with the contraction of its upper half, especially at a level one-fourth of the length of the chamber from the aperture. Pos-

sibly this is due in part to the deposition here of calcareous material on the inner wall of the shell.

The type consists of a living chamber with 5 camerae still attached. The uppermost camera is much shorter than the preceding, so that the conch is regarded as mature. The maximum expansion of the chamber is immediately above its base, where the lateral diameter is 50 mm. and the dorso-ventral one is 43 mm. Immediately above its maximum expansion the chamber contracts upward slowly for half its length, then more rapidly for a fourth of its length, there being no appreciable change within 15 mm. of the aperture. Here the lateral diameter is 41 mm. and the dorso-ventral one is 35 mm. Along the lower half of the living chamber the transverse curvature is distinctly flatter dorsally than ventrally. Along the hyponomic sinus this transverse curvature is stronger, giving a weak angulation to the median part of the ventral side of the aperture. It is estimated that originally 9 camerae occupied a length equal to the lateral diameter at the top of the phragmacone. The sutures of the septa curve less strongly downward than in *Amphicyrtoceras longidomum*. The siphuncle is about half a millimeter from the ventral wall of the conch. No. 213-A, in the Savage collection; holotype. Plate XI, figs. 1 A, B.

In a second specimen, No. 213-B (plate XI, fig. 4), the tendency toward angulation along the hyponomic sinus is more conspicuous. However, in most specimens this tendency is weak or absent.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

47. **Amphicyrtoceras brevidomum** Sp. nov.

Plate XI, figs. 3 A, B

This species is distinguished from *Amphicyrtoceras occidentale* chiefly by the smaller size of the conch and the smaller height of the living chamber compared with its lateral diameter. The living chamber used as a type varies in height from 23 mm. on its dorsal side to 26 mm. ventrally. At its greatest expansion, a short distance above the base of the living chamber, the lateral

diameter is 36.5 mm. and the dorso-ventral one is 32 mm. The constriction of the cast of its interior at one-third of its height beneath the aperture is conspicuous. The center of the siphuncle is 4 mm. from the ventral wall of the conch. No. 214-A, in the Savage collection; holotype. Plate XI, figs. 3 A, B.

In a second specimen, No. 214-B, the second and third camerae beneath the living chamber have a total height of 7 mm. Comparing this with its lateral diameter at the top of the phragmacone suggests that about 10 camerae originally occurred in a length equal to this diameter.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

48. **Amphicyrtoceras inflatum** Sp. nov.

Plate XII, figs. 1 A, B

Compared with *Amphicyrtoceras brevidomum,* the living chamber here described as *Amphicyrtoceras inflatum* is smaller, and expands for two-fifths of its length above its base before contracting conspicuously to a point about 5 mm. beneath the aperture, above which there is a slight expansion. This results in a distinctly inflated appearance. At the base of this chamber the lateral diameter is 26.5 mm., and the dorso-ventral one is estimated at 23.5 mm. Ten millimeters farther up the corresponding diameters are 30 mm. and 26 mm., narrowing to 26.5 mm. and 23 mm. at the contraction characterizing the upper part of the chamber. The height of the chamber immediately exterior to the hyponomic sinus is about 26.5 mm. A single camera, almost 2 mm. in height ventrally, is attached to the base of the living chamber. The center of the siphuncle is about 1.5 mm. from the ventral wall of the conch.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81430, in the U. S. National Museum; holotype.

49. **Amphicyrtoceras fusiforme** Sp. nov.

Plate XII, figs. 2 A, B

Compared with the preceding species, the specimen here described as *Amphicyrtoceras fusiforme* is much smaller, and the

inflation of the conch along the upper part of the phragmacone and the adjoining part of the living chamber is more conspicuous. This specimen is 41 mm. long and consists of the living chamber and 11 camerae. Its maximum expansion is at the second camera beneath the living chamber. Here its lateral diameter is 22 mm., and the dorso-ventral one is estimated at 20 mm. At the transverse groove along the upper end of the cast of the interior of the living chamber the corresponding dimensions are 17 mm. and 14 mm. The maximum height of this chamber appears to be 16 or 17 mm. Along the lower part of the living chamber and the upper part of the phragmacone the vertical outlines of the conch are convex on all sides. Along its ventral side this convexity has a radius of 35 mm. and extends from near the top of the living chamber to about the fifth camera beneath the latter. The corresponding part of its lateral outline has a radius of 30 mm. Along the gibbous part of its dorsal side the radius is 20 mm., but includes only the lower half of the living chamber, the upper half of its length presenting a concave outline. The lower part of the dorsal outline, for a length of 8 camerae, is almost straight. The corresponding lateral and dorsal outlines are gently concave. The result is a strikingly fusiform outline. The siphuncle is so close to the ventral wall of the conch that a moderate amount of weathering of the cast of its interior has exposed it along the lower margin of most of the camerae.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 22817-A, Walker Museum, University of Chicago; holotype.

50. **Amphicyrtoceras unguliforme** Sp. nov.

Plate XIII, figs. 5 A, B

Conch similar in size to *Amphicyrtoceras fusiforme*, but differing in being most inflated a little below mid-height of the living chamber. Specimen about 43 mm. long, consisting of the living chamber and 11 camerae. The rate of enlargement of the phragmacone and the lower part of the living chamber is regular up to 8 or 10 mm. above the base of the latter, above which there is only a slight contraction. The lateral diameter increases from 9 mm.

at the base of the specimen to 16.5 mm. at the base of the living chamber and to 20 mm. at a point 8 mm. farther up, diminishing to 19 mm. at the aperture. The corresponding dorso-ventral diameters are 9, 16, 18.5, and 18 mm., judging from the transverse sections of the conch as far as preserved. The ventral outline is faintly convex along the phragmacone and the lower part of the living chamber, becoming distinctly convex between 8 and 10 mm. above the base of the latter. The dorsal outline is slightly concave along the phragmacone, is faintly convex along the lower three-fifths of the living chamber, and again becomes slightly concave farther up. About 7 camerae occur in a length equal to the lateral diameter of the conch at the top of the series counted. The sutures of the septa are straight and rise slightly ventrally toward the top of the phragmacone. The siphuncle is near the ventral wall of the conch, but not in contact with the latter. No. 22817-B, Walker Museum, University of Chicago; holotype. Plate XIII, figs. 5 A, B.

In a second specimen, having about the same dimensions and form, the sutures of the septa slope slightly downward ventrally. No. 215, in the Savage collection.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

51. **Amphicyrtoceras depressum** Sp. nov.

Plate XII, figs. 4 A, B; 5 A, B; 7 A, B; plate XI, figs. 2 A, B

Specimen of about the same size as *Amphicyrtoceras inflatum*, but with the conch most expanded at the base of the living chamber or at the top of the phragmacone. Moreover, the top of the living chamber is less rapidly constricted than in that species and in *Amphicyrtoceras brevidomum*.

Specimen 53 mm. in length, not including the protruding segment of the siphuncle at its base. The dorsal outline is faintly concave along the phragmacone and faintly convex along the lower half of the living chamber, becoming slightly concave again farther up. The convex curvature of the ventral side of the conch has a radius of 80 mm. along the lower part of the phragmacone, changing to 37 mm. along the upper part of the phragmacone and

along the living chamber. At the base of the specimen its lateral diameter is estimated at 22 mm., and its dorso-ventral one is 20 mm.; at the base of the living chamber the corresponding diameters are 29 mm. and 26 mm., shortening to 24 mm. and 20 mm. about 4 mm. beneath the aperture. Above the level mentioned last there is no conspicuous change in diameter. At the base of the specimen the dorsal flattening of the transverse outline is slight; at the base of the living chamber it is conspicuous, but toward the aperture it is less conspicuous again. There is no conspicuous contraction of the upper part of the living chamber. The number of camerae within a length equal to the lateral diameter of the conch at the top of the series counted is 7. The sutures of the septa are straight or curve slightly upward ventrally. Along the lower part of the phragmacone they are nearly directly transverse to the vertical axis of the conch, but they rise at an increasing rate in a ventrad direction. The center of the segment of the siphuncle at the base of the specimen is 4 mm. from the ventral wall of the conch. Its outline is oblong, and its maximum diameter is slightly over 3 mm. No. 217 A, in the Savage collection; holotype. Plate XII, figs. 4 A, B.

A second specimen (plate XII, figs. 5 A, B), apparently belonging to the same species, includes only the living chamber, and is numbered 188 in the Savage collection. A third specimen is numbered 22817-C in Walker Museum at the University of Chicago. It includes most of the living chamber and 8 of the camerae. It is of interest chiefly on account of the downward flexure of the sutures of a number of the septa laterally. Possibly the specimen numbered 81431 (plate XII, figs, 7 A, B), in the U. S. National Museum belongs here. It has similar dorso-ventral and lateral outlines, but its camerae are relatively longer.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

Remarks.—The specimen represented by figures 2 A, B, on plate XI, is of interest chiefly on account of the decurrent sutures of some of its septa. It is numbered 22817-C, in Walker Museum, University of Chicago, and is from Port Byron.

52. **Amphicyrtoceras minimum** Sp. nov.

Plate XII, figs. 3 A, B

Living chamber differing from that of *Amphicyrtoceras brevidomum* chiefly in its much smaller size and in the absence of conspicuous contraction along the upper part of this chamber ventrally. Its maximum diameter is near the base of the chamber.

Occurrence.—Port Byron, Illinois. No. 81432, in the U. S. National Museum; holotype.

WORTHENOCERAS Gen. nov.

Genotype: *Worthenoceras elongatum* Foerste.

Conchs similar to those of *Amphicyrtoceras*, differing chiefly in their more slender proportions. In the more typical species the lower half of the living chamber is faintly convex dorsally, the lateral enlargement of the conch is small, and this enlargement continues upward for about a third of the length of the chamber. In other specimens the largest diameter is at the base of the chamber.

Named in memory of A. H. Worthen.

53. **Worthenoceras elongatum** Sp. nov.

Plate XIII, figs. 6 A, B; 7 A, B; 8 A, B

Specimen 43 mm. long, consisting of a living chamber and 4 camerae. The cross-section at its base is circular, but along the living chamber it is slightly depressed. At mid-height of the living chamber its lateral diameter is 23 mm. and its dorso-ventral one is 21 mm. Its rate of diminution above and below this point is relatively small. The sutures of the septa rise slightly ventrally, especially along the median part of the ventral side, where the uppermost sutures of the septa tend to form very low and broad saddles. No. 216-C, in the Savage collection; holotype; plate XIII, figs. 6 A, B. Specimens No. 81433, and 81433 a, in the U. S. National Museum, are similar; and are illustrated by figures 7 A, B, and 8 A, B on the same plate.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

54. **Worthenoceras byronense** Sp. nov.

Plate XIII, figs. 2 A, B; 3 A, B

Conchs similar to those of *Amphicyrtoceras elongatum*, its ventral outline is more convex at the base of the living chamber, the dorsal side of its cross-section is more distinctly flattened, and the height of its camerae is less. The dorsal outline of the conch is almost straight, with a faint convexity near the base of the living chamber, and with a faint concavity along the upper part of the phragmacone.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 316-B, 316-A, in the Savage collection cotypes; plate XIII, figs. 2 A, B; 3 A, B. Specimens No. 81434 and 81434 a, in the U. S. National Museum, belong to the same species.

55. **Worthenoceras exiguum** Sp. nov.

Plate XIII, figs. 4 A, B

Specimen consisting of a living chamber 12.5 mm. long, and a single camera, 1.6 mm. in height. The cross-section is circular, 12 mm. in diameter at the base of the living chamber, increasing to 13 mm. at mid-height. The upper part of the chamber is contracted for a length of 2 mm. immediately beneath the aperture. The siphuncle is small, and is located 1 mm. from the ventral wall of the conch.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81435, in the U. S. National Museum; holotype.

56. **Worthenoceras curtum** Sp. nov.

Plate XIII, figs. 1 A, B

Compared with *Worthenoceras elongatum* and *Worthenoceras byronense*, the conch of this species is strongly curved lengthwise. The type is 35 mm. long, and includes almost all of the living chamber and 3 camerae. At its base the lateral diameter is estimated at 22 mm., and the dorso-ventral one is almost 20 mm., the corresponding diameters at the base of the living chamber

being 23 mm. and 21 mm. At the constriction of this chamber, 13 mm. farther up, these diameters are 20.5 mm. and 17 mm. Along the ventral outline of the phragmacone 4 camerae occupy a length equal to the lateral diameter of the conch. Within the short length of the phragmacone preserved the direction of slope of the sutures of the septa changes from downward in a ventrad direction at the base of the specimen to distinctly upward at the base of the living chamber. The center of the siphuncle is 3.5 mm. from the ventral wall of the conch at the base of the specimen. The diameter of the siphuncle is 2 mm. The height of the lowest camera is 5 mm. No. 81436, in the U. S. National Museum; holotype; plate XIII, figs. 1 A, B.

A second specimen, No. 81436 a, may belong to the same species. It consists only of the living chamber. The margin of the aperture is at least 4 mm. above the deeper part of the constriction along the upper part of the chamber.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

57. **Worthenoceras crooki** Sp. nov.

Plate XII, figs. 6 A, B

Conch resembling that of *Amphicyrtoceras depressum*, but less curved along its ventral outline, and this curvature confined chiefly to the lower part of the living chamber and the top of the phragmacone. The dorso-ventral enlargement of the conch at the base of this chamber is relatively small, and the lateral enlargement of this point is inconspicuous. The camerae are slightly longer. The type is 66 mm. long. The convex curvature of its ventral outline has a radius of 125 mm. along the phragmacone, changing somewhat abruptly to 50 mm. along the living chamber. Six camerae occur in a length equal to the lateral diameter. The siphuncle is 2.6 mm. in diameter, and its center is 3.5 mm. from the ventral wall of the conch, where the dorso-ventral diameter of the latter is 17 mm.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 217-B, in the Savage collection: holotype.

Named in honor of A. R. Crook.

ECTOCYRTOCERAS Gen. nov.

Genotype: *Ectocyrtoceras marginatum* Foerste.

Living chamber similar to that of *Amphicyrtoceras*, but its dorsal outline is faintly concave, and its ventral outline is distinctly convex, so that the chamber reaches its greatest dimensions a little below mid-height both laterally and dorso-ventrally. The median part of the aperture curves slightly downward at the hyponomic sinus. The cross-section of the chamber is slightly depressed at the base of the chamber, but this depression increases a little toward the aperture. The dorsal side of the chamber is somewhat flattened, compared with its ventral side. The siphuncle is located near the ventral wall of the conch but is not in contact with the latter.

58. **Ectocyrtoceras marginatum** Sp. nov.

Plate IX, figs. 2 A, B, C

Living chamber relatively short and thick, faintly concave dorsally, and distinctly convex along its ventral outline, its radius of curvature there being 30 mm. At the base of the chamber its dorso-ventral diameter is 22 mm., its lateral one being 23 mm.; at mid-height of the chamber the corresponding diameters are 25.5 mm and 27 mm., diminishing to 23.5 mm. and 26 mm. at the contraction beneath the aperture. At the aperture the margin of the conch flares outward so as to enlarge the diameter about 1.5 mm. both dorsally and laterally, and possibly also ventrally. The slight downward curvature of the ventral margin of the aperture suggests the location of the hyponomic sinus. The siphuncle is close to the ventral wall of the conch, but not in contact with the latter.

Occurrence.—Port Byron, Illinois. No. 81437, in the U. S. National Museum; holotype.

59. **Ectocyrtoceras slocomi** Sp. nov.

Plate IX, figs. 4 A, B

The general dorsal outline of the living chamber is almost straight, there being a faint concave curvature along its lower and

upper third, with a faint convexity along its middle third. Its ventral outline is distinctly convex, its radius of curvature being 40 mm. along its lower two-thirds, above which there is a faint geniculation, followed by a lessening of the curvature. The median part of the ventral outline of the aperture curves slightly downward, thus locating the hyponomic sinus. The length of the chamber is 28 mm. and its dorso-ventral diameter at the base of the specimen is 18 mm. The cross-section is slightly depressed dorso-ventrally, its dorsal side being slightly flatter than the ventral one, especially toward the upper part of the chamber, which attains its greatest lateral diameter about two-thirds of its height above its base.

Occurrence.—Port Byron, Illinois. No. 21797-A, in Walker Museum, University of Chicago; holotype.

Named in honor of Arthur W. Slocom.

GONATOCYRTOCERAS Foerste

Genotype: *Cyrtoceras heteroclytum* Barrande, Systeme Silurien du Centre de la Boheme, 2, pt. 1, 550, pl. 118, figs. 15–18 (1867); *Gonatocyrtoceras heteroclytum* Foerste, Jour. Sci. Lab. Denison Univ., 21, 343, pl. 51, figs. 3 A-D (1926).

Conch strongly curved lengthwise, more or less knee-like in outline on lateral view. Depressed ventro-laterally, especially at the base of the living chamber. Dorsal part of cross-section more flattened than the ventral one. Lateral diameter enlarging rapidly for about half its length and then contracting strongly toward the aperture. The aperture is transversely elliptical in outline, without any indication of a hyponomic sinus. The siphuncle is located close to the ventral wall of the conch.

60. **Gonatocyrtoceras inflatum** Sp. nov.

Plate XIII, figs. 9 A, B

Compared with the genotype, the dorsal outline of this species is less concave, its ventral outline is more geniculate at mid-length, and the rate of lateral expansion is less. The length of the specimen is 53 mm. in direct measurement and 64 mm. along its

ventral outline. It enlarges from a lateral diameter of 12 mm. and a dorso-ventral one of 10.5 mm. to corresponding diameters of 27 mm. and 23.5 mm. at the base of the living chamber, and to 31 mm. and 27.5 mm. at its maximum expansion, diminishing thence to 27 mm. and 22 mm. at the aperture. The curvature of the ventral outline is moderate along the phragmacone and the upper part of the living chamber, but is strong along the lower half of this chamber where its radius is 20 mm. The number of camerae in a length equal to the lateral diameter at the top of the phragmacone is 5. The sutures of the septa are relatively straight. At the base of the specimen they are directly transverse to the curving central axis of the conch, but at the base of the living chamber they rise strongly ventrally. The siphuncle is 0.5 mm. from the ventral wall of the conch at its base, and its diameter is 1 mm. Faint transverse lines of growth curve increasingly downward ventrally.

Occurrence.—Joliet, Illinois; in the Joliet member of the Niagaran. No. 22919, in Walker Museum, University of Chicago; holotype.

EURYRIZOCERAS Gen. nov.

Genotype: *Euryrizoceras chadwicki* Foerste.

Cyrtocones with concave dorsal and convex ventral outlines, enlarging laterally at an even rate as far up as mid-height of the living chamber, and then contracting slightly toward the aperture. Moderately depressed dorso-ventrally, chiefly owing to a slight flattening of the dorsal side, especially along the living chamber. The presence or absence of a hyponomic sinus can not be determined with confidence. The sutures of the septa are nearly straight. At the lower end of the phragmacone they are nearly directly transverse to the curving central axis of the conch, but toward its upper end these sutures rise at an increasing angle in a ventrad direction. The siphuncle is close to the ventral wall of the conch but not in direct contact with the latter. Its segments are abruptly constricted at the septal necks, as in *Amphicyrtoceras*, but present a less elongated appearance within the camerae.

61. **Euryrizoceras chadwicki** Sp. nov.

Plate XIV, figs. 1 A, B; 2 A, B; 3 A, B; 4 A, B, C

Type 72 mm. in length; its dorsal side concave, even along the living chamber. The ventral side is convex. The conch enlarges laterally as far as mid-height of the living chamber and then contracts slightly toward the aperture. The convex ventral outline of the lower part of the phragmacone has a radius of 70 mm., changing to 55 mm. along the upper part of the phragmacone and all of the living chamber. At the base of the specimen the cross-section is circular, and 16 mm. in diameter. At the base of the living chamber the lateral diameter is 29 mm. and the dorso-ventral one is 27 mm.; the corresponding diameters at mid-height of this chamber being 35 mm. and 32 mm., decreasing to 33 mm. and 31 mm. at the aperture. Along the ventral outline 11 camerae occur in a length equal to the lateral diameter at the top of the series counted. The sutures of the septa are directly transverse to the curving central axis of the conch at its base but rise at an increasing angle in a ventrad direction near the top of the phragmacone. The siphuncle is near, but not in contact with the ventral wall of the conch. Plate XIV, figs. 1 A, B.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 218-A, in the Savage collection; holotype. Also Nos. 81438, 81438-A, and 81438-B in the U. S. National Museum, used for figs. 2, 3, and 4 on the same plate. In one specimen the siphuncle is fully 3 mm. in diameter near the top of the phragmacone.

Named in honor of George H. Chadwick.

62. **Euryrizoceras clinoseptatum** Sp. nov.

Plate XIV, figs. 5 A, B

Compared with *Euryrizoceras chadwicki*, this species differs chiefly in its smaller rate of enlargement, especially laterally, and in the more conspicuous rise of the sutures of the septa in a ventrad direction, resulting in more conspicuous ventral saddles. At the base of the type the cross-section is circular, the lateral diameter being 16.5 mm. at the lowest point preserved. At the

base of the living chamber its lateral diameter is 24 mm. and the dorso-ventral one is 23 mm., increasing to 29 mm. and 28 mm. respectively at mid-height of this chamber, and narrowing scarcely more than 0.5 mm. in these directions at the aperture. The slight depression of the conch dorso-ventrally is due to the slight flattening of the dorsal side of the conch at the top of the phragmacone and along the greater part of the length of the living chamber. Eleven camerae occupy a length equal to the lateral diameter at the top of the series counted, when counted along their ventral outline. The sutures of the septa rise but slightly in a ventrad direction at the base of the specimen, but at an angle of 15° above a directly transverse plane at the top of the phragmacone.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81439, in the U. S. National Museum; holotype.

63. **Euryrizoceras dispar** Sp. nov.

Plate XIV, figs. 6 A, B

Compared with *Euryrizoceras chadwicki*, the ventral outline has a similar curvature but its dorsal outline is much less concave, especially along the upper part of the conch; the sutures of the septa rise much less strongly in a ventrad direction toward the upper end of the phragmacone, and the camerae are relatively taller dorsally. The type is 57 mm. long and includes 10 camerae in addition to the living chamber. This chamber is at least 25 mm. high. The concave dorsal outline has a radius of 90 mm. Near the base of the specimen its lateral diameter is 17.5 mm. and the dorso-ventral one is 16.5 mm., the corresponding diameters at the base of the living chamber being 29 mm. and 25.5 mm., increasing to 32 mm. and 29 mm. at a point 12 mm. above this base, but not changing appreciably farther up, toward the aperture.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 219, in the Savage collection; holotype.

64. **Euryrizoceras percurvatum** Sp. nov.

Plate XVI, figs. 1 A, B; plate XV, figs. 6 A, B

This species is similar to those forms of *Eurytizoceras* just described in its circular cross-section at earlier stages of growth, changing to distinctly depressed at maturity, but differs in its greater lengthwise curvature. The type includes 10 camerae and the basal part of the living chamber. The convex ventral outline has a radius of curvature of 25 mm. along its lower half, changing to 40 mm. along its upper part. At the top of the second camera from its base the lateral diameter is 27 mm. and the dorso-ventral one is 26.5 mm., the corresponding diameters at the base of the living chamber being 42 mm. and 35.5 mm. The practically circular cross-section at its base changes to a distinctly depressed one at its top. The dorsal side is slightly flattened in comparison with its ventral one. The sutures of the septa are nearly straight but rise at an increasing rate toward the ventral side on approaching the upper part of the phragmacone. The apparently upward curvature of the lateral part of the sutures in the accompanying figure is due to the location of the specimen above the level of the central axis of the lens during photography. Five camerae occur in a length equal to the lateral diameter when counted along its ventral outline. The siphuncle is almost in direct contact with the ventral wall of the conch, and is exposed along the lower half of each camera owing to a slight weathering of its ventral surface.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 22818, Walker Museum, University of Chicago; holotype. Plate XVI, figs. 1 A, B.

Remarks.—A fragment of a phragmacone, 55 mm. in length along its ventral outline, represented by figures 6 A, B, on plate XV, may be a more apical part of a conch similar to or identical with *Eurytizoceras percurvatum*. It is numbered 81441 in the U. S. National Museum.

65. **Euryrizoceras plenum** Sp. nov.

Plate XI, figs. 5 A, B

Compared with *Euryrizoceras percurvatum*, the specimen described here is less curved lengthwise, especially along its dorsal outline; moreover, it enlarges more rapidly in a dorso-ventral direction. Unfortunately, the living chamber of *Euryrizoceras percurvatum* is unknown, and this presents some of the most characteristic features of *Euryrizoceras plenum*, the living chamber of the latter being relatively short and broad and contracting somewhat rapidly toward the aperture in a lateral direction. The type consists of the living chamber with 3 camerae attached. The lateral diameter increases from 35 mm. at the base of the specimen to 45 mm. at the base of the living chamber, and 46.5 mm. near mid-height of the latter, contracting thence to 40.5 mm. near the aperture. The corresponding dorso-ventral diameters are 29 mm., 36 mm., 38 mm., and 37 mm. A little weathering has exposed the siphuncle, which is close to the ventral wall of the conch. Its segments appear vertically elliptical, 5 mm. in diameter, and abruptly contracted at the septal necks.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81440, in the U. S. National Museum; holotype.

SLOCOMOCERAS Gen. nov.

Genotype: *Slocomoceras retrorsum* Foerste.

Cyrtocones with nearly circular or slightly depressed cross-sections, their living chambers varying but slightly in dimensions along their length though usually tapering slightly along their upper part. Aperture nearly circular; the presence or absence of a hyponomic sinus can not be determined from the specimens at hand. The sutures of the septa are directly transverse dorsally and laterally, but curve conspicuously downward along the middle of the ventral side of the conch. The siphuncle is located close to the ventral wall of the conch, but is not in contact with the latter. Its segments are contracted abruptly and narrowly at the septal necks, but enlarge within the camerae somewhat as in *Amphicyrtoceras*, but are not as strongly elongated.

64. **Euryrizoceras percurvatum** Sp. nov.

Plate XVI, figs. 1 A, B; plate XV, figs. 6 A, B

This species is similar to those forms of *Euryrizoceras* just described in its circular cross-section at earlier stages of growth, changing to distinctly depressed at maturity, but differs in its greater lengthwise curvature. The type includes 10 camerae and the basal part of the living chamber. The convex ventral outline has a radius of curvature of 25 mm. along its lower half, changing to 40 mm. along its upper part. At the top of the second camera from its base the lateral diameter is 27 mm. and the dorso-ventral one is 26.5 mm., the corresponding diameters at the base of the living chamber being 42 mm. and 35.5 mm. The practically circular cross-section at its base changes to a distinctly depressed one at its top. The dorsal side is slightly flattened in comparison with its ventral one. The sutures of the septa are nearly straight but rise at an increasing rate toward the ventral side on approaching the upper part of the phragmacone. The apparently upward curvature of the lateral part of the sutures in the accompanying figure is due to the location of the specimen above the level of the central axis of the lens during photography. Five camerae occur in a length equal to the lateral diameter when counted along its ventral outline. The siphuncle is almost in direct contact with the ventral wall of the conch, and is exposed along the lower half of each camera owing to a slight weathering of its ventral surface.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 22818, Walker Museum, University of Chicago; holotype. Plate XVI, figs. 1 A, B.

Remarks.—A fragment of a phragmacone, 55 mm. in length along its ventral outline, represented by figures 6 A, B, on plate XV, may be a more apical part of a conch similar to or identical with *Euryrizoceras percurvatum*. It is numbered 81441 in the U. S. National Museum.

65. **Euryrizoceras plenum** Sp. nov.

Plate XI, figs. 5 A, B

Compared with *Euryrizoceras percurvatum*, the specimen described here is less curved lengthwise, especially along its dorsal outline; moreover, it enlarges more rapidly in a dorso-ventral direction. Unfortunately, the living chamber of *Euryrizoceras percurvatum* is unknown, and this presents some of the most characteristic features of *Euryrizoceras plenum*, the living chamber of the latter being relatively short and broad and contracting somewhat rapidly toward the aperture in a lateral direction. The type consists of the living chamber with 3 camerae attached. The lateral diameter increases from 35 mm. at the base of the specimen to 45 mm. at the base of the living chamber, and 46.5 mm. near mid-height of the latter, contracting thence to 40.5 mm. near the aperture. The corresponding dorso-ventral diameters are 29 mm., 36 mm., 38 mm., and 37 mm. A little weathering has exposed the siphuncle, which is close to the ventral wall of the conch. Its segments appear vertically elliptical, 5 mm. in diameter, and abruptly contracted at the septal necks.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81440, in the U. S. National Museum; holotype.

SLOCOMOCERAS Gen. nov.

Genotype: *Slocomoceras retrorsum* Foerste.

Cyrtocones with nearly circular or slightly depressed cross-sections, their living chambers varying but slightly in dimensions along their length though usually tapering slightly along their upper part. Aperture nearly circular; the presence or absence of a hyponomic sinus can not be determined from the specimens at hand. The sutures of the septa are directly transverse dorsally and laterally, but curve conspicuously downward along the middle of the ventral side of the conch. The siphuncle is located close to the ventral wall of the conch, but is not in contact with the latter. Its segments are contracted abruptly and narrowly at the septal necks, but enlarge within the camerae somewhat as in *Amphicyrtoceras*, but are not as strongly elongated.

Named in honor of A. W. Slocom, for many years curator of Walker Museum, at the University of Chicago, and very helpful to the present writer in the course of his studies.

66. **Slocomoceras retrorsum** Sp. nov.

Plate XV, figs. 1 A, B; 2 A, B; 3 A, B, C; 4; 5

Type 85 mm. in length along its ventral outline, the radius of curvature of the latter being 60 mm., the corresponding radius of the concave dorsal outline being 50 mm. The length of the living chamber is 45 mm.; 8 camerae are attached. The lateral diameter enlarges from 28 mm. at the top of the second camera above the base of the specimen to 34 mm. at the base of the living chamber and 35.5 mm. at 7 mm. above the latter, diminishing to 34 mm. at the aperture. The dorso-ventral diameter enlarges from 29 mm. at the base of the fourth camera beneath the living chamber to 32.5 mm. at the base of the latter, and 34 mm. at 7 mm. farther up, diminishing to 33 mm. at the aperture. The dorso-ventral depression of the conch therefore is slight. About 7 camerae occur in a length equal to the dorso-ventral diameter at the top of the series counted. The sutures of the septa are nearly directly transverse along the dorsal and lateral sides of the conch but curve strongly downward along the median part of its ventral side, for a distance equalling about half the height of a camera. The siphuncle is located close to the ventral wall of the conch, but not in contact with the latter. Its segments are inflated within the camerae and strongly and abruptly contracted at the septal necks, very much as in *Amphicyrtoceras*. The dorsal vertical outlines of these segments is nearly straight, and their ventral outlines are moderately convex, sloping outward toward the lower part of each segment. The surface of the cast of the interior of the phragmacone is ribbed vertically, the ribs being low and faint, except under cross-illumination.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. The holotype (plate XV, figs. 1 A, B) is No. 81442, in the U. S. National Museum. Additional specimens are Nos. 81442-a, 81442-b, 81442-c, and 81442-d, represented by figures 2 A, B;

3 A, B, C; 4, and 5 in the same plate. The last two show the structure of the siphuncle.

BYRONOCERAS Foerste and Savage

Genotype: *Byronoceras longidomum* Foerste. Jour. Sci. Lab. Denison Univ., 22, 82, pl. 24, figs. 3 A, B (1927).

Conch moderately curved lengthwise, with its ventral outline convex. Almost circular in cross-section, slightly depressed, with the siphuncle almost in contact with the ventral wall. Sutures of the septa straight and directly transverse to the length of the conch or rising moderately in a ventrad direction toward the upper part of the phragmacone. Segments of the siphuncle obliquely oval or globular, their obliquity being due to their location near the ventral wall of the conch where the septa curve strongly downward owing to their concavity.

67. **Byronoceras longidomum** Foerste amd Savage

Plate XVI, figs. 3 A, B

Byronoceras longidomum Foerste and Savage, Jour. Sci. Lab., Denison Univ., 22, 82, pl. 24, figs. 3 A, B (1927).

Specimen 58 mm. in length along its convex ventral outline. Of this length 35 mm. belongs to the living chamber and 23 mm. is occupied by 5 camerae. The radius of curvature of this ventral outline is 70 mm., that of the concave dorsal outline being 60 mm. The conch enlarges dorso-ventrally from 22 mm. at its base to 23.5 mm. at the base of the living chamber, and then maintains the latter diameter as far as the aperture. The lateral diameter enlarges from 23 mm. at the base of the specimen to 25 mm. at the base of the chamber, and to 26.5 mm. a little above mid-height of the latter, thence not changing as far as the aperture. Five camerae occupy a length equal to the dorso-ventral diameter of the conch. The sutures of the septa are nearly straight but rise in a ventrad direction. At the base of the fifth camera beneath the living chamber this rise is slight, but it increases successively at each suture farther up. The siphuncle is close to the ventral wall of the conch and readily exposed by a slight weather-

ing of the surface of the cast of its interior. Possibly the upper part of each segment is in actual contact. These segments slope steeply toward the interior of the conch. The contraction at the septal necks is strong and abrupt.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81443, in the U. S. National Museum; holotype.

Remarks.—This species is characterized by its elongate living chamber, its almost straight sutures of the septa, and the increasing rise of these sutures in a ventrad direction on approaching the upper part of the phragmacone.

68. **Byronoceras transversale** Sp. nov.

Plate XVI, figs. 2 A, B, C

Conch similar to *Byronoceras longidomum*, but attaining a larger size. At the base of the living chamber its dorso-ventral diameter is 27 mm. and its lateral one is 28 mm. Its dorsal side is slightly flatter along the upper part of the phragmacone and the lower part of the living chamber. The number of its camerae is relatively greater, equalling about 7 in a length equal to the dorso-ventral diameter of the conch. The sutures of the septa are nearly straight and do not rise in a ventrad direction as in the preceding species.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81444, in the U. S. National Museum holotype.

69. **Byronoceras paulocurvatum** Sp. nov.

Plate XVII, figs. 2 A, B

Conch similar to *Byronoceras longidomum*, but with relatively shorter camerae. Living chamber 35 mm. long, with 3 camerae attached. The total length of these camerae is 7 mm. along their ventral outline. This convex ventral outline has a radius of curvature of 40 mm., that of the concave dorsal outline being 80 mm. The dorso-ventral diameter enlarges from 17 mm. at its base to 21 mm. at mid-height of the living chamber, and diminishes to 19.5 mm. at its aperture. The corresponding lateral diameters are 18 mm., 23 mm., and 22 mm. The aperture appar-

ently had a very shallow hyponomic sinus along the median part of its ventral side, but this is uncertain. The sutures of the septa are directly transverse. The siphuncle is located close to the ventral wall of the conch, but is not in direct contact with the latter. Its segments are elongate, as in *Amphicyrtoceras*.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 22893; in Walker Museum, University of Chicago; holotype.

70. **Byronoceras commune** Sp. nov.

Plate XVI, figs. 4 A, B

Conch similar to *Byronoceras transversale*, but with the sutures of the septa curving distinctly downward laterally, and rising ventrally. Six camerae occupy a length equal to the dorso-ventral diameter.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. The type is numbered 81445, in the U. S. National Museum; holotype. Other specimens are Nos. 81445-a, and 81445-b.

ANOMEIOCERAS Gen. nov.

Genotype: *Anomeioceras compressum* Foerste.

Conchs differing from *Byronoceras* chiefly in the much stronger curvature of the conch, and the greater contraction of the living chamber toward its aperture. The sutures of the septa curve downward laterally, rising moderately in a dorsad direction and strongly in a ventrad one, especially in case of those near the living chamber. The siphuncle apparently is similar to that of *Amphicyrtoceras*.

71. **Anomeioceras compressum** Sp. nov.

Plate XVII, figs. 6 A, B

Conch 55 mm. long if measured along its convex ventral outline, the radius of curvature of the latter being 40 mm. The lower part of the specimen is compressed laterally, the dorso-ventral diameter at its base being 26 mm., and the lateral one only 23 mm. At the base of the living chamber the cross-section is more nearly circular, the corresponding diameters being 29.5 mm. and 28.5

mm. Toward the aperture the living chamber contracts, the dorso-ventral one not being known definitely, but the lateral one is 27.5 mm. At 7 mm. above the base of the living chamber both diameters are 30 mm., this being the maximum diameter of the conch. The sutures of the septa curve slightly downward laterally, but rise strongly ventrally, especially near the living chamber, forming broad ventral saddles. Owing to the geniculate curvature of the upper part of the phragmacone, the sutures here appear to rise at increasing angles in a ventrad direction, on approaching the living chamber. About 5.5 camerae occur in a length equal to the dorso-ventral diameter of the conch at the top of the series counted. The siphuncle is almost in contact with the ventral wall of the conch.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81446, in the U. S. National Museum; holotype.

Remarks.—This species is characterized by its lateral compression at earlier stages of growth, changing to circular along the lower part of the living chamber, the latter contracting toward the aperture. The conch curves in a geniculate manner along the upper part of the phragmacone. The sutures of the septa curve downward laterally and rise at an increasing rate ventrally on approaching the living chamber.

71a. **Anomeioceras savagei** Sp. nov.

Plate XVII, figs. 3 A, B

Specimen consisting of a living chamber with three camerae still attached. The radius of curvature of the convex ventral outline is 40 mm. The conch contracts conspicuously along the living chamber toward the aperture, especially in a dorso-ventral direction. Compared with *Anomeioceras compressum*, this species is more slender, and the sutures of the septa curve less strongly upward in a ventrad direction, especially in the vicinity of the living chamber.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. Specimen No. S-196, in the Savage collection.

Named in honor of Thomas E. Savage.

72. **Anomeioceras vicinum** Sp. nov.

Plate XVI, figs. 5 A, B

Conch differing from *Anomeioceras compressum* chiefly in the relatively greater rise of the sutures of its septa ventrally, at the top of the phragmacone; moreover the upper part of the living chamber is slightly depressed dorso-ventrally. The type is 55 mm. long when measured along its convex ventral outline. The radius of curvature of the latter is 35 mm. Its dorso-ventral diameter enlarges from 26 mm. at its base to 30 mm. at the base of the living chamber and contracts to 26 mm. again at the uppermost part preserved. The lateral diameter enlarges from 25.5 mm. at the base of the specimen to 31 mm. at 7 mm. above the base of the living chamber, contracting thence to 27.5 mm. at the aperture. The sutures of the septa curve slightly downward laterally, and rise toward the ventral side of the conch, forming broad ventral saddles.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 224, in the Savage collection; holotype.

73. **Anomeioceras brevicameratum** Sp. nov.

Plate XVII, figs. 4 A, B; 5

Type consisting of the lower part of a living chamber with 3 camerae attached. Compared with *Anomeioceras compressum*, the camerae are more closely crowded dorsally, and the ventral outline of its cross-section is more flattened at the top of the phragmacone. At the base of the first camera beneath the living chamber the lateral diameter is 24 mm. and the dorso-ventral one is estimated at 26 mm. The lateral diameter contracts to 19 mm. at the top of the specimen. Its ventral outline is distinctly convex, and its dorsal one is slightly concave. The general dorso-ventral outline of the conch probably resembled that of *Anomeioceras compressum*. The sutures of the septa curve slightly downward laterally, and rise strongly in a ventrad direction, especially in case of the septa nearest the living chamber. It is estimated that 7 camerae occurred in a length equal to the dorso-

ventral diameter of the conch. No. 81447, in the U. S. National Museum; holotype. Plate XVII, figs. A, B.

A small fragment of a phragmacone, including 5 camerae, enlarges rapidly dorso-ventrally from 21 mm. at its base to 25 mm. at its top, the corresponding lateral diameters being 20 mm. and 23 mm. Their total length is 9 mm. dorsally and 18 mm. ventrally. The siphuncle is located almost in contact with the ventral wall of the conch, and its segments, though poorly preserved, appear similar to those of *Amphicyrtoceras*. No. 81447-a. in the U. S. National Museum. Plate XVII, fig. 5.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

PERIOIDANOCERAS Gen. nov.

Genotype: *Perioidanoceras rotundatum* Foerste.

Conch circular in cross-section, rapidly enlarging and strongly curved. Dorsal outline gibbous along the upper end of the phragmacone. Sutures of the septa curving only faintly downward, but rising at a moderate angle ventrally. The siphuncle is almost in contact with the ventral wall of the conch, and its segments are similar to those of *Amphicyrtoceras*, contracting abruptly at the septal necks which are very short.

74. **Perioidanoceras rotundatum** Sp. nov.

Plate XVII, figs. 1 A, B

The type consists of a phragmacone including 10 camerae. Its convex ventral outline has a radius of 60 mm. The lower and middle part of the dorsal outline is curved concavely with a radius of 30 mm., changing to a convex curvature with radius of 80 mm. along the upper 3 camerae. It is assumed that the gibbosity of the upper part of the dorsal side of the phragmacone extended also to the lower part of the living chamber. The dorso-ventral diameter enlarges from 43 mm. at its base to 66 mm. at its top. The corresponding lateral diameters are 41 mm. and 65 mm., the cross-section being nearly circular. About 9 camerae occur in a length equal to the dorso-ventral diameter of the conch at the top of the series counted. The sutures of the septa curve faintly

downward laterally, but rise at a low angle in a ventrad direction. No. 195, in the Savage collection; holotype. Plate XVII, figs. 1 A, B.

A closely similar specimen, numbered 223 in the same collection, includes 6 camerae, and has a diameter of 81 mm. at its top. There is no evidence of a gibbous outline along its dorsal side and the lengthwise curvature of its ventral outline is less, but it is possible that it belongs to a lower part of a phragmacone which may have been more gibbous farther up. In this second specimen the siphuncle is near the ventral wall of the conch, but not in actual contact with the latter. The form of its segments is similar to that of *Amphicyrtoceras*.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

CHADWICKOCERAS Gen. nov.

Genotype: *Chadwickoceras fusiforme* Foerste.

Conchs straight, fusiform, with their maximum enlargement near the top of the phragmacone or at the base of the living chamber; dorso-ventrally depressed. The living chamber tapers upward to the transversely elliptical aperture. The dorsal side of this chamber is slightly flatter than the ventral one. The siphuncle is near the ventral wall of the conch but not in contact with the latter. Its segments resemble those of *Amphicyrtoceras*, and contract strongly and abruptly at the septal necks. In general appearance these conchs resemble *Diestoceras*, but they are depressed dorso-ventrally instead of laterally. The presence or absence of a hyponomic sinus can not be determined definitely.

Named in honor of George H. Chadwick.

Chadwickoceras fusiforme and *Chadwickoceras pauper* evidently are closely related. In the same manner *Chadwickoceras ellipticum* and *Chadwickoceras erectum* are closely related to each other, but their affinities to typical *Chadwickoceras* are not so certain. Their affinities may be nearer *Amphicyrtoceras*, but their conchs appear more nearly straight, rather than more or less curved lengthwise.

ventral diameter of the conch. No. 81447, in the U. S. National Museum; holotype. Plate XVII, figs. A, B.

A small fragment of a phragmacone, including 5 camerae, enlarges rapidly dorso-ventrally from 21 mm. at its base to 25 mm. at its top, the corresponding lateral diameters being 20 mm. and 23 mm. Their total length is 9 mm. dorsally and 18 mm. ventrally. The siphuncle is located almost in contact with the ventral wall of the conch, and its segments, though poorly preserved, appear similar to those of *Amphicyrtoceras*. No. 81447-a. in the U. S. National Museum. Plate XVII, fig. 5.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

PERIOIDANOCERAS Gen. nov.

Genotype: *Perioidanoceras rotundatum* Foerste.

Conch circular in cross-section, rapidly enlarging and strongly curved. Dorsal outline gibbous along the upper end of the phragmacone. Sutures of the septa curving only faintly downward, but rising at a moderate angle ventrally. The siphuncle is almost in contact with the ventral wall of the conch, and its segments are similar to those of *Amphicyrtoceras*, contracting abruptly at the septal necks which are very short.

74. **Perioidanoceras rotundatum** Sp. nov.

Plate XVII, figs. 1 A, B

The type consists of a phragmacone including 10 camerae. Its convex ventral outline has a radius of 60 mm. The lower and middle part of the dorsal outline is curved concavely with a radius of 30 mm., changing to a convex curvature with radius of 80 mm. along the upper 3 camerae. It is assumed that the gibbosity of the upper part of the dorsal side of the phragmacone extended also to the lower part of the living chamber. The dorso-ventral diameter enlarges from 43 mm. at its base to 66 mm. at its top. The corresponding lateral diameters are 41 mm. and 65 mm., the cross-section being nearly circular. About 9 camerae occur in a length equal to the dorso-ventral diameter of the conch at the top of the series counted. The sutures of the septa curve faintly

downward laterally, but rise at a low angle in a ventrad direction. No. 195, in the Savage collection; holotype. Plate XVII, figs. 1 A, B.

A closely similar specimen, numbered 223 in the same collection, includes 6 camerae, and has a diameter of 81 mm. at its top. There is no evidence of a gibbous outline along its dorsal side and the lengthwise curvature of its ventral outline is less, but it is possible that it belongs to a lower part of a phragmacone which may have been more gibbous farther up. In this second specimen the siphuncle is near the ventral wall of the conch, but not in actual contact with the latter. The form of its segments is similar to that of *Amphicyrtoceras*.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

CHADWICKOCERAS Gen. nov.

Genotype: *Chadwickoceras fusiforme* Foerste.

Conchs straight, fusiform, with their maximum enlargement near the top of the phragmacone or at the base of the living chamber; dorso-ventrally depressed. The living chamber tapers upward to the transversely elliptical aperture. The dorsal side of this chamber is slightly flatter than the ventral one. The siphuncle is near the ventral wall of the conch but not in contact with the latter. Its segments resemble those of *Amphicyrtoceras*, and contract strongly and abruptly at the septal necks. In general appearance these conchs resemble *Diestoceras*, but they are depressed dorso-ventrally instead of laterally. The presence or absence of a hyponomic sinus can not be determined definitely.

Named in honor of George H. Chadwick.

Chadwickoceras fusiforme and *Chadwickoceras pauper* evidently are closely related. In the same manner *Chadwickoceras ellipticum* and *Chadwickoceras erectum* are closely related to each other, but their affinities to typical *Chadwickoceras* are not so certain. Their affinities may be nearer *Amphicyrtoceras*, but their conchs appear more nearly straight, rather than more or less curved lengthwise.

75. **Chadwickoceras fusiforme** Sp. nov.

Plate XVIII, figs. 1 A, B

The type is 96 mm. long, 43 mm. being occupied by the living chamber. In a lateral direction the lower part of the phragmacone enlarges at an apical angle of 37 degrees, the upper 3 camerae and most of the living chamber curving convexly with a radius of 70 mm. In a dorso-ventral direction the angle of enlargement is 35 degrees, and the radius of curvature of the upper part of the conch is nearer 80 mm., but with a tendency toward straightening along both the ventral and the dorsal outline along the upper part of the living chamber, especially along the dorsal side. At the base of the first camera beneath the living chamber the dorso-ventral diameter is 56 mm. and the lateral one is 59 mm. Ten millimeters above the base of this chamber these diameters are 48.5 mm. and 56.5 mm.; and 20 mm. farther up they are 37 mm. and 44 mm. The dorso-ventral depression of the conch is slight at the top of the phragmacone but is conspicuous along the living chamber. Nine camerae occur in a length equal to the dorso-ventral diameter of the conch. The sutures of the septa are straight and slope faintly downward in a ventrad direction, but the uppermost one or two camerae tend to enlarge vertically in that direction, thus decreasing slightly the slope of the uppermost sutures. The cast of the interior of the living chamber is narrowly annulated about 4 mm. above its base, this annulation being narrower and more sharply elevated dorsally. Immediately above this annulation there is an inward curvature of the vertical outlines of the chamber for a height of 5 mm. The margin of the aperture is not clearly defined. Possibly there is a hyponomic sinus 10 mm. deep and 25 mm. wide, similar to that of *Amphicyrtoceras* rather than that of *Gomphoceras*, but the state of preservation of the type leaves this uncertain. No. 220-A, in the Savage collection; holotype. Plate XVIII, figs. 1 A, B.

A second specimen, No. 220-B in the same collection, consists of the basal part of the living chamber and 7 camerae of the phragmacone. In this specimen the maximum lateral diameter is 54 mm. The siphuncle is exposed from the third to the sixth

camera beneath the living chamber. In the upper one of these camerae the siphuncle is 5 mm. wide and 1.5 mm. distant from the ventral wall of the conch. The segments are oblong in lateral outline, but are abruptly constricted at the septal necks, as in *Amphicyrtoceras*.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

76. **Chadwickoceras pauper** Sp. nov.

Plate XVIII, figs. 3 A, B

Conch closely similar to *Chadwickoceras subfusiforme*, but considerably smaller, and its maximum enlargement is above the base of the living chamber on dorsal view but at the level of this base on lateral view, in both cases at a higher level than in the species named. The type is 58 mm. long, erect, and enlarges at an angle of 33 degrees as far as a point 3 mm. above the base of the living chamber on dorsal view, above which the lateral outlines curve convexly with a radius of 40 mm. until near the aperture. The ventral outline presents a similar curvature, but the dorsal side of the chamber is distinctly flattened and presents a nearly straight vertical outline. At the base of the living chamber the dorso-ventral diameter is 36 mm. and its lateral one is estimated at 37 mm. At 25 mm. above this base the corresponding diameters are 24 mm. and 30 mm., indicating the distinct dorso-ventral depression of the upper part of the living chamber. Dorsally this chamber is 28 mm. high. Ventrally a height of 26 mm. is preserved, without trace of a hyponomic sinus. About 9 camerae occur in a length equal to the dorso-ventral diameter of the conch. The sutures of the septa are straight and directly transverse to the vertical axis of the conch. The siphuncle is exposed along the entire length of the phragmacone. At its top its diameter is nearly 4 mm., and its distance from the ventral wall of the conch is 0.5 mm. along the lower part of each camera, being distinctly more distant along the upper part of the camera. The general structure of its segments is as in the genotype. The surface of the shell is relatively smooth, but may have been faintly striated transversely.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 221, in the Savage collection; holotype.

77. **Chadwickoceras ellipticum** Sp. nov.

Plate XVII, figs. 7 A, B

Compared with the preceding species of *Chadwickoceras*, the conch is considerably smaller and its sides are more evenly convex, both laterally and dorso-ventrally. The type is 32 mm. long, of which 17 mm. belongs to the living chamber. Its central vertical axis is straight. The conch is depressed dorso-ventrally. At the base of the living chamber the lateral diameter is 26 mm. and the dorso-ventral one is 22.5 mm. Twelve millimeters above the base of this chamber the corresponding diameters are 21 mm. and 18 mm. The original height of the chamber was at least 15 mm., but there is no definite outline of its aperture, nor any trace of a hyponomic sinus. Originally there were about 9 camerae in a length equal to the dorso-ventral diameter of the conch. The sutures of the septa are almost straight, but curve slightly downward ventrally. One segment of the siphuncle is exposed at the base of the specimen. It is 2 mm. in diameter and is 0.5 mm. from the ventral wall of the conch, the dorso-ventral diameter of the conch here being 16 mm.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 222, in the Savage collection; holotype.

78. **Chadwickoceras erectum** Sp. nov.

Plate XVIII, figs. 2 A, B

Conch differing from *Chadwickoceras ellipticum* in its smaller rate of enlargement laterally, resulting in a less elliptical, but more elongate aspect, when viewed from the ventral or dorsal side. The type is 32 mm. long, of which 15 mm. belongs to the living chamber. The convex lateral outlines have a radius of curvature of 60 mm. along the phragmacone, changing to 30 mm. along the living chamber. The convex curvature of its ventral outline has a radius of 100 mm. along the phragmacone, changing to 30 mm.

along the living chamber. The radius of curvature of the dorsal outline is about 45 mm. along most of the conch, changing from convex to slightly concave along the upper part of the living chamber. The conch attains its maximum diameter about 1.5 mm. above the base of this chamber, its lateral diameter here being 22 mm., and its dorso-ventral one is estimated at 20 mm. At the top of the living chamber the corresponding diameters are 17 mm. and 14.5 mm., the former being estimated. There is no trace of a hyponomic sinus. About 8 camerae occur in a length equal to the dorso-ventral diameter. The sutures of the septa are straight and directly transverse. The passage of the siphuncle through the septum at the base of the specimen is 1.2 mm. in diameter, and its margin is half a millimeter from the ventral wall of the conch, the dorso-ventral diameter here being estimated at 12 mm. At the base of the specimen the cross-section of the conch is nearly circular, becoming increasingly depressed toward the base of the living chamber.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81448, in the U. S. National Museum; holotype.

PHRAGMOCERAS Broderip

Genotype: *Phragmoceras arcuatum* Sowerby, in Murchison's Silurian System, 621, pl. 10, fig. 1A (1839); Blake, British Fossil Cephalopoda, 204, pl. 26, figs. 1, 1A (1882); Foerste, Jour. Sci. Lab. Denison Univ., 21, 350, pl. 48, figs. 1 A, B (1926)

In this genotype, the dorsal outline of the living chamber curves backward, giving rise to a short dorsal collar whose upper edge forms the margin of the dorsal expansion of the aperture. Conch strongly compressed laterally and strongly curved lengthwise, with its ventral outline concave. At the hyponomic sinus, the ventral outline curves strongly forward, forming a spout-like projection. The general form of the dorsal expansion of the aperture is ovate, its ventro-lateral sides converging at a more or less acute angle toward the narrowly contracted part of this aperture.

79. **Phragmoceras byronense** Worthen

Phragmoceras byronensis Worthen, Geol. Surv. Illinois, 6, 506, pl. 24, fig. 6 (1875); Foerste, Jour. Sci. Lab. Denison Univ., 24, pl. 61, figs. 1 A, B (1929).

A detailed description of the type, accompanied by two figures, is presented in the preceding number of this bulletin, cited above. This type was found at Rock Island, Illinois, is an erratic block, and it differs sufficiently from the similar specimens found at Port Byron to warrant the separation of the latter under a distinctive specific name, *Phragmoceras wortheni*. The type of *Phragmoceras byronense* is numbered 12100 in the Illinois State Museum of Natural history, at Springfield, Illinois.

80. **Phragmoceras wortheni** Sp. nov.

Plate XIX, figs. 1, 2; plate XVIII, fig. 5

Conch similar to *Phragmoceras byronense*, but the aperture of the living chamber begins to contract while the dorso-ventral diameter of the conch at the base of this chamber is only about 40 mm., instead of 50 mm., and the living chamber is more slender the ratio of the length of the ventral outline between the base of this chamber and the lip-like projection of the hyponomic sinus to the dorso-ventral diameter at the base of the chamber being as 35 to 40, the corresponding ratio in the case of typical *Phragmoceras byronense* being as 30 to 50. The specimen represented by fig. 1 on plate XIX is selected as the holotype, and is numbered 201-C, in the Savage collection. The original of fig. 2 on the same plate is numbered 201-A. Figure 5 on plate XVIII is part of a phagmacone showing decurrent sutures of septa.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

Named in memory of A. H. Worthen.

80a. **Phragmoceras** sp. (Port Byron)

Plate XXI, fig. 7; plate XVIII, fig. 4

The specimen represented on plate XXI is of interest on account of its narrowly decurrent sutures of the septa ventro-later-

ally. In the specimen figured on plate XVIII, the upper sutures are curved downward laterally along a much greater width. The camerae are relatively taller than in *Phragmoceras byronense* and *Phragmoceras wortheni*, and the lengthwise curvature of the larger specimen is greater than in those species at the same stage of growth. In the absence of adequate knowledge of the living chamber, nothing more definite can be determined as to their relationship.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. Specimens no. S-202, and S-203, in the Savage collection.

81. **Phragmoceras vicinum** Sp. nov.

Plate XX, fig. 4

Living chamber similar to that of *Phragmoceras byronense*, but more erect, neither its dorsal nor its ventral outline curving as far forward in a ventrad direction, compared with the course of the suture at its base. Moreover, this chamber is relatively not as tall at the dorsal end of the narrowly contracted part of the aperture, compared with the dorso-ventral diameter at its base. Finally, its ventral outline, as far up as the base of the spout-like projection of the hyponomic sinus, is not as long, compared with the same dorso-ventral diameter. Hence, the general appearance of the chamber is lower and broader on lateral view than in the species named.

Occurrence.—Port Byron, Illinois. No. 200-D, in the Savage collection; holotype.

82. **Phragmoceras chicagoense** Foerste

Plate XIX, figs. 8, 9

Phragmoceras chicagoense Foerste, Jour. Sci. Lab., Denison Univ., 24, 339, pl. 63, figs. 3 A, B; 4 A, B (1929).

Specimen consisting of a living chamber with a dorso-ventral diameter of 39 mm. and a lateral one of 29 mm. at its base. The dorsal outline is nearly at right angle with the suture of the septum at its base, but the ventral outline slopes forward at an angle

of 20 degrees with the vertical. The linearly contracted part of the aperture slopes in a ventrad direction at an angle of 20 degrees with the suture named. The dorsal end of the aperture terminates in a transversely elliptical lobe having a lateral diameter of 21 mm. and a dorso-ventral one of 11.5 mm. along the median line of the lobe and 9 mm. laterally. This dorsal lobe is supported on a dorsal neck whose lower margin is distinctly outlined by its angulate contact with the body of the chamber. The dorsal face of this neck is weakly trilobate, the middle lobe being 10 mm. wide. The surface of the shell is transversely striated, the striae curving downward for a short distance ventrally and for a longer distance dorsally. About 10 of these striae occur in a length of 10 mm. along the lateral sides of the chamber. No., 22922-A, Walker Museum, University of Chicago; holotype. Plate XIX, fig. 8.

A second specimen, numbered 22922-B in the same collection, preserves the dorsal neck for a length of 9 mm. The dorsal margin is distinctly, though only slightly trilobate. Along the median part of the dorsal lobe of the aperture, that part of the shell which is nearest the narrowly contracted part of the aperture extends backward in a dentate manner. The lip formed by the hyponomic sinus projects abruptly forward. Plate XIX, fig. 9.

Occurrence.—Cicero, Cook county, Illinois; in the Racine. Additional specimens include No. 22057, from McCooks, and No. 21973, from Hawthorne, both in the Chicago area.

83. **Phragmoceras arcanum** Sp. nov.

Plate XIX, fig. 7

Living chamber similar to that of *Phragmoceras altidorsatum* Foerste (Jour. Sci. Lab. Denison Univ., 24, 329, pl. 57, fig. 3, 1929), in general outline, but not distinctly humped at mid-height dorsally, nor gibbous a short distance below the spout-like projection ventrally. Moreover, the chamber is not as tall at the dorsal end of the narrowly contracted part of the aperture, compared with the dorso-ventral diameter of the chamber at its base. The type consists of a living chamber with 7 camerae attached. Of these, the upper two camerae are distinctly shorter than the rest.

The dorsal outline has a radius of curvature of 45 mm. The dorso-ventral diameter at the base of the living chamber is 36 mm., and the lateral one is 28 mm. The dorsal end of the linearly contracted part of the aperture rises 36 mm. above the suture at its base. The spout-like projection at the hyponomic sinus projects abruptly forward. Only the basal part of the dorsal neck is preserved. This has a lateral diameter of 20 mm. and a dorso-ventral one of 16 mm., the exact form of the dorsal lobe not being preserved. About 7.5 camerae occur in a length equal to the dorso-ventral diameter at the base of the living chamber, when counted along their dorsal outline.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 205-A, in the Savage collection; holotype.

84. **Phragmoceras ontarioense** Foerste

Plate XIX, figs. 3 A, B; 4 A, B; 5; 6

Phragmoceras ontarioense Foerste, Jour. Sci. Lab. Denison Univ., 24, 349, pl. 58, figs. 2 A, B (1929).

Living chambers closely similar to those of *Phragmoceras ontarioense* and not distinguishable from the latter in the present state of knowledge of the two species. The dorsal neck, which supports the dorsal lobe of the aperture, is somewhat abruptly limited at its base from the body of the chamber by a relatively narrow and shallow transverse groove. The upper part of its dorsal side is distinctly trilobate, apparently by the ingrowth of two dental projections 1 mm. in length and 5.5 mm. apart. The lateral diameter of the upper part of this neck is 13 mm. and its dorso-ventral one is 7 or 8 mm. The ventral outline of the dorsal lobe of the aperture is indented, on both sides of the dorsal termination of the narrowly contracted part of the aperture, by the backward growth of the adjacent part of the shell. No. 206-A, in the Savage collection (plate XIX, figs. 3 A, B). Also Nos. 81449, and 81449a, in the U. S. National Museum, represented by figures 4 A, B, and 5, on the same plate.

A cast of a similar living chamber, retaining the upper part of the phragmacone, apparently retains traces of transverse mark-

ings, such as frequently occur on the surface of shells of *Phragmoceras*. About 9 of these occur in a length of 10 mm. No. 1122, Illinois State University. Plate XIX, fig. 6.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

INVERSOCERAS Hedström

Genotype: *Phragmoceras perversum* Barrande, Systeme Silurien du Centre de la Boheme, 2, text 1, 241, pl. 53, figs. 1–6; Foerste, Jour. Sci. Lab. Denison Univ., 21, 355, pl. 35, figs. 4 A-D (1926). See also Hedström, Sveriges Geol. Undersökning, ser. Ca, no. 15, 7 (1917).

Conch moderately curved, its ventral outline being convex and its dorsal outline concave, except in the immediate vicinity of the aperture. The dorsal collar projects upward and backward, and its lateral margin is narrowly incised by a V-shaped sinus. The remainder of the aperture is similar to that of typical *Phragmoceras*. The type is from Kozorz, Bohemia; in the Middle Silurian, at Barrande's horizon E.

From this type, the Racine species here described as *Inversoceras dayi* differs in the absence of the lateral V-shaped incisions along the dorsal lobe of the aperture. Similar incurvatures of the lateral margins of the dorsal enlargement of the aperture, but much wider, occur in several of the species of *Phragmoceras* described by Hedström in the publication cited above. These include *Phragmoceras acuminatum, Phr. discoideum, Phr. gigas, Phr. gradatum, Phr. liljevalli, Phr. parvulum, Phr. sigmoideum, Phr. simile,* and *Phr. undulatum.* Only in *Phragmoceras inflexum* is this incurvature narrowed into an almost horizontal slit.

85. **Inversoceras** (?) **dayi** Sp. nov.

Plate XXV, figs. 10, 11, 12, 13

Conch curved in a direction opposite to that of typical *Phragmoceras,* its dorsal outline being gently concave along the phragmacone and the lower third of the living chamber; the dorsal outline of the living chamber is slightly convex along its lower two thirds, becoming concave on approaching the dorsal neck which

supports the dorsal lobe of the aperture. The ventral outline is convex except at the spout-like projection at the hyponomic sinus; the convexity is greatest along the living chamber. The linearly contracted part of the aperture slopes downward in a ventrad direction at an angle of 30 degrees with the horizontal. The dorsal side of the dorsal neck is weakly impressed on each side of the plane of symmetry, resulting in a weak trilobation of its cross-section. About 6 or 7 camerae occupy a length equal to the dorso-ventral diameter, when counted along its ventral outline. The sutures of the septa are almost straight, and directly transverse to the curving central axis of the conch. Plate XXV fig. 10.

Occurrence.—Schoonmaker quarry, in Wauwatosa, Wisconsin in the Racine. Specimens no. 2164 and 2158, in the Museum of Comparative Zoology, Harvard University. Cotypes.

Named in memory of Dr. H. Day, whose collections have enriched the Museum of Comparative Zoology.

Remarks.—Compared with typical *Inversoceras perversum* (Barrande), the most striking difference is the absence of the narrowly incised V-shaped sinus on each of the lateral sides of the dorsal neck or collar, and in the presence of the weakly defined trilobation of the posterior side of this neck. In addition, the dorsal outline of the conch is more strongly concave, and its ventral outline is more strongly convex, at least along the living chamber.

TUBIFEROCERAS Hedström

Genotype: *Phragmoceras proboscideum* Hedström, Ueber die Gattung Phragmoceras in der Obersilurformation Gotlands, Sveriges Geol. Undersöking, Upp. Avh., Ser. Ca, no. 15, 8, 11 (1917). *Tubiferoceras proboscideum* Foerste, Jour. Sci. Lab., Denison Univ., 21, 352, pl. 48, figs. 2 A-C (1926); 24, 360 (1929).

This genus was founded on a species in which the dorsal lobe of the aperture is supported by a dorsal neck which curves abruptly backward and upward from the upper part of the body of the living chamber, and is delimited from the latter by a shallow exterior groove and a relatively low but sharply defined interior

ridge. This ridge is most elevated along the lower part of the dorsal side of the neck, and rises diagonally upward and inward toward the upper part of the interior of the chamber. In a second species, *Phragmoceras prominens*, and its variety *minus*, the dorsal neck projects obliquely backward with only a slight convexity of its dorsal outline. The characteristic feature of the genus is the oblique ridge within the interior of the living chamber which delimits the base of the dorsal neck from the lower part of the body of the chamber.

The species described by Kindle and Breger from the Huntingdon formation of northern Indiana under the name *Trimeroceras gilberti* is a typical representative of this genus, and *Phragmoceras labiatum* Whitfield, from the Lower Coral bed in the Waukesha dolomite of Ashford, south of Fond-du-Lac, Wisconsin, is another. The species described by Newell from the Liston creek limestone of Wabash, in northern Indiana as *Gomphoceras lineare*, probably belongs to this genus.

Two species from the Port Byron dolomite of northwestern Illinois are referred here to *Tubiferoceras*, although the elevation of the oblique ridges at the base of their dorsal necks is very low, compared with more typical representatives of the genus. However, the general form of the conch is closely similar.

86. **Tubiferoceras savagei** Sp. nov.

Plate XX, figs. 1; 2 A, B; 3 A, B

Type 65 mm. long, of which 38 mm. belongs to the living chamber. The convex dorsal outline has a radius of 70 mm. as far up as the groove outlining the dorsal neck of the living chamber. This neck projects backward at an angle of 10 degrees from the vertical, while the limiting groove slopes forward at 45 degrees. The ventral outline is nearly straight as far up as the groove outlining the basal part of the spout-like projection at the hyponomic sinus. The dorso-ventral apical angle is 47 degrees along the lower part of the phragmacone, the corresponding lateral angle being 27 degrees. At the base of the living chamber the dorso-ventral diameter is 48 mm. and the lateral one is 39 mm. At

mid-height of this chamber the lateral diameter is 42.5 mm., the dorso-ventral diameter increasing to 57 mm. at the base of the dorsal neck and the ventral spout-like projection. The top of the living chamber slopes at an angle of 6 degrees in a ventrad direction compared with the suture of the septum at its base. At least 12 camerae occur in a length equal to the lateral diameter of the conch, when counted along its dorsal outline. The sutures of the septa are straight, but diverge slightly in a dorsad direction. The siphuncle is located close to the ventral wall of the conch at a distance slightly less than the diameter of its passage through the septa. No. 207-B, in the Savage collections; holotype. Plate XX, fig. 1.

In an isolated living chamber with a dorso-ventral diameter of 49 mm. at its base, the groove outlining the base of the dorsal neck is 20 mm. above the base of the chamber. The dorsal outline of this neck slopes backward at an angle of 20 degrees with the perpendicular, the limiting groove sloping 45 degrees forward. The passage of the siphuncle through the septum at the base of the chamber is 3 mm. in diameter and its margin is 2 mm. from the ventral wall of the conch. The general outline of the dorsal lobe of its aperture is as in *Phragmoceras nestor*. No. 207-A, in the Savage collection. Plate XX, figs. 2 A, B.

A third specimen, numbered 1142 in the museum of the University of Illinois, differs from the preceding only in being moderately larger and in presenting a straighter outline dorsally. Its dorso-ventral diameter at the base of the living chamber is 53 mm., the corresponding lateral diameter being 46 mm., enlarging to 50 mm. at mid-height of this chamber. Three camerae are attached. The lateral diameter of the segment of the siphuncle at its base is 4 mm., and its distance from the ventral wall of the conch also is 4 mm. Plate XX, figs. 3 A, B.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

MANDALOCERAS Hyatt

Genotype: *Gomphoceras bohemicum* Barrande, Systeme Silurien du Centre de la Boheme, 306, pl. 74, figs. 12–16 (1867); *Man-*

daloceras bohemicum Hyatt, in Zittel-Eastman's Text-book of Paleontology, 531, figs. 1084 A, B (1900); Foerste, Jour. Sci. Lab. Denison Univ., 21, 359, pl. 48, figs. 5 A-C (1926); 24, 369 (1929).

Conchs erect; ventral outline more convex than the dorsal one; cross-section nearly circular, slightly less convex dorsally; sutures of septa straight and directly transverse; siphuncle about half-way between the center of the conch and its ventral wall. The aperture is distinctly T-shaped, its dorsal end forming two narrow lobes extending strictly in a lateral direction, with their ends curving slightly forward, in a ventrad direction. The posterior border of the aperture, extending along the rear of the two postero-lateral lobes, curves slightly forward along its median part.

In the American species here discussed, the earlier stages of the gerontic aperture pass through a more nearly Y-shaped form. Later, the margin of the lateral crests bordering on the aperture continues its growth in a backward direction so as to become more nearly T-shaped, but in none of these species do the postero-lateral lobes become as long and narrow as in the genotype.

87. **Mandaloceras scrinium** (Hall)

Plate XXI, figs. 1, 2; plate XXII, fig. 9

Gomphoceras scrinium Hall, 20th Rep. New York State Cab. Nat. Hist., 350, pl. 18, figs. 1–3 (1868); *Mandaloceras scrinium* Foerste, Jour. Sci. Lab. Denison Univ., 24, 370, pl. 62, figs. 3 A, B (1929).

Compared with the figure of *Mandaloceras marcyae* published by Winchell and Marcy, the living chamber of the type of *Mandaloceras scrinium* is shorter and more dumpy, its maximum diameter being only a short distance above its base. The aperture has a Y-shaped outline, its lateral margins diverging in a dorsad direction, while its dorsal outline curves forward between the dorso-lateral lobes, as well illustrated by Hall.

Occurrence.—Bridgeport, in the southern part of Chicago,

Illinois; in the Racine. No. 2114, American Museum of Natural History; holotype. For fuller description including figures of this type, see last publication cited above.

Another Chicago specimen consists of a living chamber with a single camera attached. At 10 mm. above the suture at its base the lateral diameter is 38 mm. and the dorso-ventral one is 41 mm. The height of the chamber is 32 mm. The general form of the chamber is more globose than in the type. The groove outlining the basal part of the dorso-lateral lobes of the aperture is 25 mm. above the suture at its base, the corresponding elevation of the spout-like projection at the hyponomic sinus being 20 mm. The outlines of the aperture are broadly Y-shaped. No. 25847-A, Walker Museum, University of Chicago. Plate XXI, fig. 1.

Another specimen in the same museum, numbered 18106-B, is from Hawthorne, west of Chicago. As here represented by fig. 2 on plate XXI, its dorsal outline is on the left. Its specific identity is not certain, but its camerae are much taller than those figured by Winchell and Marcy in *Gomphoceras marcyae*.

Specimen No. 18106-R, from the same locality as the preceding, is a living chamber a little smaller than that of the type of *Mandaloceras scrinium*, and it is less inflated directly above the suture of the septum at its base, but the chamber is distinctly lower than in typical *Mandaloceras marcyae*. Its chief interest lies in the more narrow constriction of the dorso-lateral and ventral lobes of the aperture, and in the lateral margins of the latter becoming so nearly parallel that the general form of this aperture approaches that of a T rather than that of a Y. Apparently this implies a more advanced gerontic stage, rather than a distinct species. Plate XXII, fig. 9.

Remarks.—The type of *Mandaloceras marcyae* was figured by Winchell as having a T-shaped aperture, its lateral sides being more nearly parallel, and its dorsal outline curving convexly outward, instead of concavely inward. No specimens having an aperture strictly conformable to that figured by Winchell are known from the Racine of either Illinois or southeastern Wisconsin.

88. **Mandaloceras marcyae** (Winchell and Marcy)

Plate XXI, fig. 3

Gomphoceras Marcyae Winchell and Marcy, Mem. Boston Soc. Nat. Hist., 1, 101, pl. 3, figs. 8 A, B (1865); Foerste, Jour. Sci. Lab. Denison Univ., 24, 371 (1929).

The publication of *Gomphoceras marcyae* was preceded by that of *Gomphoceras scrinium* Hall, and both Hall and Winchell regarded these species as identical. However, if the figures published by Winchell and Marcy are at all reliable, these species are readily distinguishable. In fig. 8b of *Gomphoceras marcyae*, cited above, the aperture is figured as T-shaped, with its dorsal outline convex instead of distinctly concave. Moreover, the living chamber included in fig. 6a is relatively taller, compared with its dorso-ventral diameter. This figure is so oriented as to present a direct view of the right dorso-lateral lobe of the aperture. On its left is an oblique view of the dorsal crest of the shell, bordering on the posterior margin of the two dorso-lateral lobes. On its right is the highest elevation attained by the shell at the dorsal end of of the ventral lobe. This ventral lobe is not in sight.

Unfortunately, that part of the aperture illustrated by fig. 8a does not appear to permit such an outline as that shown in fig. 8b. The dorsal crest of the shell here appears to curve forward, rather than backward, as though the aperture were Y-shaped, instead of T-shaped. Moreover, no T-shaped aperture has been noticed in the relatively numerous specimens of living chambers of this general type coming from the Chicago area. In the absence of a T-shaped aperture, only the greater tallness of the chamber and its smaller diameter remain as diagnostic features.

In that case, such a living chamber as that represented here by fig. 3 on plate XXI may be accepted provisionally as the nearest approach to the specimen figured by Winchell and Marcy. No. 21895, Walker Museum, University of Chicago. From the Chicago area.

89. **Mandaloceras hawthornense** Sp. nov.

Plate XXI, figs. 6, 4 A, B

Mandaloceras hawthornense differs from *Mandaloceras scrinium* chiefly in its larger size; moreover, the two dorso-lateral lobes diverge from the linearly contracted ventral lobe of the aperture more nearly at a right angle.

The type includes the ventral half of the living chamber and of 8 camerae. The lateral outline of the conch is elliptical, its maximum diameter being 5 mm. below the suture at the base of the chamber. The maximum height of this chamber is 40 mm. The linearly contracted ventral lobe widens but slightly toward its dorsal end, so that the two dorso-lateral lobes diverge from the latter almost at right angles. The upper margin of these lobes is 9 mm. above the groove outlining their base. The conch evidently was slightly compressed laterally. The uppermost camera is 2 mm. in height, followed in descending order by camerae 5, 6, 6, 5.5, 4.5, and 4.5 mm. in height. No. 21967-B, in Walker Museum, University of Chicago; holotype. Plate XXI, fig. 6.

A living chamber, 43 mm. in height, has a lateral diameter of 45 mm. and a dorso-ventral one of 50.5 mm. Compared with the type, the narrowly contracted ventral lobe of the aperture widens more dorsally, and the two dorso-lateral lobes diverge from the latter at angles of about 100 degrees. This aperture apparently has reached a less gerontic stage than that of the type. The lateral extremities of the dorsal lobes of the aperture are 3 mm. above the groove outlining their base. The crest of the dorsal side of the shell arches distinctly upward and forward. No. 81450, in the U. S. National Museum. Plate XXI, figs. 4 A, B.

Occurrence.—Hawthorne, west of Chicago, Illinois; in the Racine.

90. **Mandaloceras diminuens** Sp. nov.

Plate XXI, figs. 5 A, B

The type is a cast of the interior of a living chamber 17 mm. in height. At its base the lateral diameter is 19 mm., and the dorso-ventral one is 20 mm. This chamber contracts almost evenly for

a height of about 13 mm., above which it contracts abruptly to a lateral diameter of 12 mm. and a dorso-ventral one of 13 mm. above which the contraction continues at a smaller rate. The transverse line of sudden contraction is lower ventrally than laterally or dorsally. The aperture is only partially preserved, but sufficient remains to suggest that this chamber belongs to the genus *Mandaloceras*. Aside from its small size, this chamber is characterized by the abrupt contraction of its upper part, as described above.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 22816, Walker Museum, University of Chicago; holotype.

HEXAMEROCERAS Hyatt

Genotype: *Phragmoceras panderi* Barrande, Systeme Silurien du Centre de la Boheme, 2. pt. 1, 232, pl. 48, figs. 12–15 (1867); *Hexameroceras panderi* Hyatt, Proc. Boston Soc. Nat. Hist., 22, 278 (1884); Foerste, Jour. Sci. Lab. Denison Univ., 21, 362, pl. 50, figs. 3 A-C (1926); 24, 373 (1929).

Dorsal outline of conch convex; ventral outline concave along the phragmacone and convex along the living chamber and the adjacent part of the phragmacone. Dorsal end of the aperture contracted so as to leave 6 lobes. Of these, the 2 anterior lobes are directed ventro-laterally; the middle pair are directed slightly posterior to directly lateral; and the posterior pair are short and are directed straight back from points located along the posterior border of the dorsal expansion of the aperture. The only American species presenting this type of aperture is *Pristeroceras timidum* Ruedemann.

All other American species possessing 6 lobes along this dorsal expansion of the aperture have 2 posterior lobes which are directed laterally rather than posteriorly, and their length is fully equal to that of the middle pair or even exceeds the latter. Along the median line of the dorsal side of the aperture the adjacent part of the shell curves upward and inward in the form of a distinct crest. This type of structure is shown also by the species described by Barrande under the name *Phragmoceras callistoma*,

as figured on plate 47of his monumental work cited above. Among American species, the one described by Hall as *Gomphoceras septoris* also shows this type of structure, though erroneously referred recently to *Septameroceras*.

91. **Hexameroceras septore** (Hall)

Plate XXII, fig. 7

Gomphoceras septoris Hall, 20th Rep. New York State Cab. Nat. Hist., 350, figs. 9, 10 (1868); *Septameroceras septoris* Grabau and Shimer, North Amer. Index Fossils, 2, 131, fig. 1379 (1910); *Hexameroceras septore* Foerste, Jour. Sci. Lab. Denison Univ., 21, 357 (1926); 24, 376, pl. 62, figs. 2 A-C (1929).

The lateral view of the living chamber of the type of this species is here reproduced, for comparison with the other species here described. Other views are presented in the preceding volume of this bulletin, cited above.

Occurrence.—Wauwatosa, Wisconsin; in the Racine. Specimen no. 12649, Walker Museum, University of Chicago; holotype

92. **Hexameroceras byronense** Sp. nov.

Plate XXII, figs. 1 A, B, C; 2 A, B

Living chamber with an aperture similar to that of *Hexameroceras septore*, but larger, and relatively depressed vertically, instead of convergent in a conical manner toward its top. Its lateral diameter is 31 mm. and the dorso-ventral one is 35 mm. at the base of the chamber, the height of the chamber being 28 mm. The linearly contracted part of the aperture slopes downward in a ventrad direction at an angle of 15 degrees with the horizontal. No. 209-B, in the Savage collection; holotype. Plate XXII, figs. 1 A, B, C.

Specimen No. 209-A, from the same collection, has a less indented outline along the median part of the dorsal margin of the aperture. Plate XXII, fig. 2 A, B.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

93. **Hexameroceras depressum** Sp. nov.

Plate XXII, figs. 3 A, B

Aperture similar to that of the second specimen described under *Hexameroceras byronense,* but the ventral outline is relatively taller and much less incurved at the spout-like projection of the hyponomic sinus. That part of the conch in contact with the linearly contracted part of the aperture is conspicuously elevated on lateral view. The top of the dorsal outline of the chamber curves more abruptly inward. In consequence the top of this chamber appears more abruptly terminated.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 2150-D, Museum of Comparative Zoology, Harvard University; holotype.

94. **Hexameroceras arctilobatum** Sp. nov.

Plate XXII, figs. 5 A, B

The outline of the aperture differs from that of the second specimen described under *Hexameroceras byronense* in the narrower width of its lobes. Theoretically this should be an evidence merely of more gerontic conditions; however, the living chamber is taller, and its dorsal outline is more convexly curved. The resultant dorso-ventral outline of the living chamber is readily distinguishable. The maximum lateral diameter is 24 mm., and the dorso-ventral one is 28 mm., both being located 8 or 9 mm. above the base of the chamber. The height of the chamber is 27 mm.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 22813-C, Walker Museum, University of Chicago; holotype.

95. **Hexameroceras globosum** Sp. nov.

Plate XXII, figs. 8 A, B

Compared with *Hexameroceras arctilobatum,* the dorso-ventral outline of the living chamber is more nearly circular, the concavity of the septum at its base being much greater, the resulting form being more globose. The maximum lateral diameter of

this chamber is 15 mm. and its dorso-ventral one is 18.5 mm., both diameters being 5 mm. above the suture of the septum at its base. The lower side of the spot-like projection of the hyponomic sinus and the groove limiting the lower margin of the dorso-lateral lobes of the aperture are 14 mm. above this suture. The linearly contracted part of the aperture slopes downward in a ventrad direction at an angle of 15° with the horizontal. The middle and anterior pairs of lobes are so poorly preserved as to be scarcely recognizable. The concavity of the septum at the base of the living chamber is 9 mm., thus giving the chamber, as a whole, a remarkably globose appearance.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 22813-K, Walker Museum, University of Chicago; holotype.

96. **Hexameroceras compressum** Sp. nov.

Plate XXII, fig. 6

Hexameroceras hertzeri Foerste, Jour. Sci. Lab. Denison Univ., 24, 376, pl. 49, figs. 5 A, B (1929).

Several specimens have been found in the Moodie quarry, at Wilmington, Ohio, which formerly were identified with *Hexameroceras hertzeri*. They differ from the latter, however, in being strongly compressed laterally. At first, this compression was supposed to be due to flattening of the shell after the death of the animal, but such flattening is not characteristic of the various fossils found in this quarry, not even of the thin shelled forms. Recently other differences were noted. All of the compressed forms are of smaller size. The ventral outline of the living chamber is less convex and is relatively higher and more erect, so that the top of the chamber, along the narrowly contracted part of the aperture, slopes less strongly downward in a ventrad direction. The sutures of the septa rise more strongly in a dorsad direction, compared with the ventral outline at the top of the phragmacone and the adjacent part of the living chamber. Since the form appears distinguishable in several respects, a new name here is proposed. The specimen belonging to the Welch collection unquestionably offers the most information and therefore is

selected as the holotype, but that belonging to the Walker museum, at the University of Chicago will serve as an excellent cotype.

The dorso-ventral diameter of the latter is 27 mm. at the base of the living chamber, the corresponding lateral diameter being estimated at 18 mm. The dorsal outline is convexly curved with a radius of 25 mm., that of the ventral outline being 60 mm. The lower margin of the spout-like projection at the hyponomic sinus is 14 mm. The suture at the base of the living chamber rises in a dorsad direction at an angle of 80 degrees with the ventral outline of the conch at the base of this chamber and the adjacent part of the phragmacone.

Occurrence.—Wilmington, Ohio; in the Cedarville dolomite, which is equivalent to the Racine of Wisconsin and northern Illinois. No. 2159, Walker Museum, University of Chicago.

97. **Hexameroceras jolietense** Sp. nov.

Plate XXII, fig. 4

Conch with about the same dorso-ventral diameter at the base of the living chamber as in *Hexameroceras hertzeri*, but it is more erect, less curved lengthwise, and enlarges at a slower rate. The ventral margin of the living chamber is taller, and the top of this chamber, along the narrowly contracted part of the aperture, slopes in a ventrad direction at a smaller angle with the horizontal. Along the dorsal side of the conch the radius of convex curvature is 50 mm. Along the phragmacone the ventral outline is concave, changing to convex along the upper part of this phragmacone and the living chamber, with a radius of 60 mm. At the base of the living chamber its dorso-ventral diameter is 42 mm. The height of this chamber is 33 mm. Both the lower margin of the spout-like projection of the hyponomic sinus and the lower margin of the dorso-lateral lobes of the aperture are 23 mm. above the suture of the septum at the base of the chamber. The dorsal crest of the shell rises distinctly between the 2 dorso-lateral lobes. The uppermost camera is distinctly shorter than those beneath. About 9 camerae occur in a length equal to the dorso-ventral diameter of

the conch at the top of the phragmacone, when counted along its dorsal outline.

Occurrence.—Joliet, Illinois; in the Joliet dolomite. No. 22941, Walker Museum, University of Chicago; holotype.

98. **Hexameroceras** cf. **hertzeri** (Hall and Whitfield)

Plate XXIII, figs. 3 A-C

Cyrtoceras hertzeri Hall and Whitfield, Geol. Surv. Ohio, 2, 150, pl. 8, figs. 7, 8 (1875); *Hexameroceras hertzeri* Grabau and Shimer, North Am. Index Fossils, 2, 130, fig. 1378 (1910); Foerste, Jour. Sci. Lab. Denison Univ., 24, 375, pl. 49, figs. 1 A, B; 2, 3 A, B (1929).

Conch slightly more curved lengthwise than in typical *Hexameroceras hertzeri,* both dorsally and ventrally. The camerae are essentially of the same length when measured along the dorsal outline of the conch, however, since the dorso-ventral diameter at the base of the living chamber is a little less, the relative number of these camerae in a length equal to the dorso-ventral diameter is correspondingly greater. Unfortunately, the aperture is not preserved, and in its absence it is not possible to definitely correlate this Port Byron specimen with the Ohio species named above.

Occurrence.—Port Byron, Illinois. No. 2150-B, Museum of Comparative Zoology, Harvard University.

99. **Hexameroceras** (?) **turgidum** Sp. nov.

Plate XXIII, fig. 7

Conch 90 mm. long, 53 mm. of this length belonging to the living chamber. Eight camerae still are attached. The dorsal outline is strongly convex, its radius of curvature being 52 mm.; the corresponding radius of the convexly curved ventral outline is 60 mm. The rate of expansion of the lower end of the specimen is so rapid that any possibility of a concave curvature along the lower part of the ventral outline of the phragmacone appears to be out of question. The base of the spout-like projection of the hyponomic sinus is 36 mm. above the suture of the septum at the base

of the living chamber. The narrowly linear part of the aperture is 17 mm. long and slopes downward in a ventrad direction at an angle of 20° compared with the suture at the base of the living chamber. Dorsally the aperture spreads over a width of 30 mm. and dorso-ventrally over an area 23 mm. in length, but no trace of the lobation of the aperture within this area remains, so that the reference of this specimen to *Hexameroceras* is only tentative. The maximum dorso-ventral diameter of the living chamber is 66 mm., the corresponding lateral diameter being 61 mm., both about 13 mm. above the suture of the septum at its base. The siphuncle is not exposed. The surface of the shell, as far as known, is smooth.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite No. 208, in the Savage collection; holotype.

PENTAMEROCERAS Hyatt

Genotype: *Gomphoceras mirum* Barrande, Systeme Silurian du Centre de la Boheme, 2, pt. 1, 319, pl. 82, figs. 17–25 (1867); *Pentameroceras mirum* Foerste, Jour. Sci. Lab. Denison Univ., 21, 356, pl. 50, figs. 6 A-C (1926); 24, 379 (1929).

Conch erect, ventral outline slightly more convex than the dorsal one; cross-section depressed dorso-ventrally. The dorsal expansion of the aperture is divided into 5 lobes. Of these the dorsal lobe is relatively short and directed straight backward. The posterior pair of lateral lobes are much longer and have a strictly lateral direction. The anterior pair of lateral lobes is of intermediate length and is directed ventro-laterally. The greater part of the ventral lobe is very narrow, but enlarges abruptly at the hyponomic sinus where it protrudes in the form of a short spout.

Species of *Pentameroceras* occur in the Racine at Milwaukee and Wauwatosa, Wisconsin; in the Huntingdon formation of northern Indiana; in the Peebles dolomite of Adams county in southwestern Ohio; and in the Port Byron dolomite of northwestern Illinois. All of these resemble *Pentameroceras mirum*, but are distinguishable specifically. For the Port Byron form the name *Pentameroceras byronense* here is proposed.

Parks described a species from either the Ekwan or Attawapiskat limestone on Severn river, west of Hudson Bay, under the name *Pentameroceras rarum.*

100. **Pentameroceras byronense** Sp. nov.

Plate XXIII, figs. 5 A-C, 6

Living chamber enlarging rather evenly in a dorso-ventral direction along the lower two-thirds of its height, the upper part of the ventral outline curving evenly inward toward the base of the spout-like projection of the hyponomic sinus, and the corresponding part of the dorsal outline curving abruptly inward toward the basal part of the dorsal and dorso-lateral lobes.

In one specimen, 22 mm. in height, the lateral diameter at the base of the living chamber is 15 mm., the dorso-ventral one being 13.5 mm.; the corresponding diameters at a point 11 mm. above the base are 17 mm. and 16 mm. No. 22814-A, Walker Museum, University of Chicago, (plate XXIII, fig. 6). A second specimen is more nearly circular in cross-section. Its height is 19 mm., and its dorso-ventral diameter increases from 14 mm. at the base of the chamber to 16 mm. at a point 7 or 8 mm. farther up. It is numbered 22814-B (plate XXIII, figs. 5 A, B, C). A third specimen, numbered 22814-C, but not figured, is distinctly compressed laterally. It is 16.5 mm. in height, and its maximum lateral diameter is 14.5 mm. where its dorso-ventral one is 16.5 mm., both about 5 or 6 mm. above the base of the chamber.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. In Walker Museum, University of Chicago, cotypes.

Remarks.—Compared with the genotype, *Pentameroceras mirum,* the enlargement of the living chamber in an upward direction along its lower two-thirds is the most striking difference. Moreover, the 5 lobes of the dorsal expansion are wider, and somewhat shorter, and are more conspicuously set off from the adjacent part of the chamber.

STENOGOMPHOCERAS Foerste

Genotype: *Stenogomphoceras chadwicki* Foerste, Jour. Sci. Lab. Denison Univ., 24, 367, pl. 61, figs. 2 A-D (1929).

Conch strongly compressed laterally, so that the living chamber appears tall when viewed from its ventral or dorsal side. This chamber usually is more or less distinctly constricted above mid-height, the constriction being broad and shallow and becoming indistinct ventrally. The form of the aperture is known only in the genotype. In its most constricted form it shows a large dorsal expansion, a narrow and relatively short linear part, and a somewhat expanded ventral termination at the hyponomic sinus. This ventral termination extends down the steep slope of the upper part of the ventral side of the chamber. The large dorsal expansion of the aperture presents two dorso-lateral lobes and one dorsal lobe, all broadly rounded; also two ventro-lateral lobes which are more prominent though much narrower. This type of structure is represented by fig. 1 D on pl. XXIV; fig. 2 B on the same plate is regarded as representing an earlier stage of development, showing more incipient stages in the contraction of the aperture. Most of the other specimens present only the earlier stages of development, or do not preserve the aperture at all. The sutures of the septa curve downward laterally and form dorsal and ventral saddles, of which the ventral ones tend to be more narrowly rounded. The siphuncle is located near the ventral wall of the conch.

101. **Stenogomphoceras chadwicki** Foerste.

Plate XXIV, figs. 1 A-D, 2 A, B; plate XXIII, figs. 1 A, B

Stenogomphoceras chadwicki Foerste, Jour. Sci. Lab. Denison Univ., 24, 368, pl. 61, figs. 2 A-D (1929).

The character of the aperture in the two specimens here figured has been indicated sufficiently in the description of the genus. The living chamber of the type (plate XXIV, figs. 1 A, B, C, D) is about 32 mm. in height at the most elevated part of the aperture. At the base of the chamber the lateral diameter is 22 mm. and the dorso-ventral one is 27 mm. At the transverse groove 16 mm. above this base the corresponding diameters are 19 mm. and 23 mm. An additional contraction takes place 2 mm. beneath the aperture, where the lateral diameter is 17 mm., there being a

distinct expansion at the margin of the aperture. The lower margin of the spout-like projection at the hyponomic sinus is 19 mm. above the ventral saddle at the base of the chamber. The linearly contracted part of the aperture slopes in a ventrad direction at an angle of 25° with the horizontal. The antero-lateral lobation of the dorsal expansion of the aperture is known only in the type specimen where it is poorly defined. However, apparently there is a faint indication of the incipient stage of such a lobe also in the second specimen here figured. Along the lower part of the chamber, the ventral side of the cross-section is slightly more narrowly rounded than the dorsal side. The suture of the septum at its base is distinctly curved downward laterally.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. The type is No. 81451, in the U. S. National Museum; holotype. The second specimen figured (plate XXIV, figs. 2 A, B) is No. 1117 in the museum of the University of Illinois.

Named in honor of George H. Chadwick.

102. **Stenogomphoceras inflatum** Sp. nov.

Plate XXIV, figs. 3 A, B; 4 A, B, C; 7 A, B, C; plate XXIII, figs. 2 A, B

Compared with *Stenogomphoceras chadwicki*, the lower part of the living chamber enlarges more conspicuously in a lateral direction for a distance equalling two-fifths of its height above the base, and then contracts to a shallow groove whose deepest part is three-fifths of its height above the base. This groove is nearly 5 mm. wide in a vertical direction and rises slightly dorsally but more strongly ventrally, although it becomes very faint in the latter direction.

The type specimen is preserved for a height of 25 mm. It consists chiefly of a living chamber, with two low camerae at its base. At this base the dorso-ventral diameter is 28 mm. and the lateral one is 30.5 mm., enlarging to 23 mm. at a level 8 mm. farther up, and then contracting to 18.5 mm. at a point 15 mm. above the base of the chamber, the lateral diameter at the aperture being still smaller. The course of the broad groove at the contraction

a little above mid-height of the chamber is well shown. There is a trace of the base of the spout-like projection of the hyponomic sinus about 17 mm. above the base of the chamber. No. 227, in the Savage collection; holotype. Plate XXIV, figs. 3 A, B.

A second living chamber (plate XXIV, figs. 4 A, B, C), preserved for a height of 28 mm., has a dorso-ventral diameter of 28 mm. and a lateral one of 22 mm. at its base. At a point 9 mm. above this base the corresponding diameters are 29 mm. and 25 mm., diminishing to 25.5 mm. and 21 mm. at the contraction above mid-height of the chamber. At the aperture the lateral diameter is only 19 mm. The lower part of the spout-like projection of the hyponomic sinus is 22 mm. above the suture at the base. This suture curves downward laterally. The passage of the siphuncle through the septum at the base of this chamber is 1.5 mm. in diameter, and is 1 mm. from the ventral wall of the conch. No. 81452, in the U. S. National Museum. In a third specimen (plate XXIV, figs. 7 A, B, C), numbered 81452-a in the same museum, the basal part of the living chamber and three of the camerae are preserved. The lateral enlargement of the lower part of the chamber is well shown. The camerae are relatively tall, about 9 or 10 occurring in a length equal to the dorso-ventral diameter of the conch at the top of the phragmacone.

In another specimen (plate XXIV, figs. 2 A, B), retaining the greater part of the living chamber but not its aperture, and including also the upper 5 camerae, it is estimated that at least 10 or 11 camerae occurred originally in a length equal to the dorso-ventral diameter at the top of the phragmacone. No. 210, in the Savage collection.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite.

103. **Stenogomphoceras contractum** Sp. nov.

Plate XXIV, figs. 5 A, B; plate XXIII, figs. 4 A, B

Compared with *Stenogomphoceras contractum*, the height of the living chamber (plate XXIV, figs. 5 A, B) is lower and its lower half contracts more conspicuously in an upward direction both laterally and dorso-ventrally. At the base of the chamber its

lateral diameter is estimated at 24.5 mm. and the dorso-ventral one is 29 mm. At the contraction 11 mm. above its base the corresponding diameters are 20 mm. and 23.5 mm. This contraction continues as far as the aperture where the lateral diameter is only 16 mm. The base of the spout-like projection at the hyponomic sinus is 16 mm. above the base of the chamber, the groove outlining the faint lateral lobe of the dorsal expansion of the aperture being 21 mm. above this base.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81453, in the U. S. National Museum; holotype.

Remarks.—The specimen represented by figs. 4 A, B, on pl. XXIII, may belong to this species. It is of interest chiefly in showing the form and structure of the phragmacone.

104. **Stenogomphoceras pusillum** Sp. nov.

Plate XXIV, figs. 6 A, B

Compared with *Stenogomphoceras contractum,* the living chamber is smaller, the suture of the septum at its base curves more strongly downward laterally, and the shallow groove at the contraction of the chamber is more distinctly above mid-height and curves more strongly upward ventrally. At the base of the specimen its lateral diameter is estimated at 19.5 mm. and the dorso-ventral one is 23 mm.; contracting to corresponding diameters of 15 mm. and 17.5 mm. at the groove mentioned above. The spout-like projection at the hyponomic sinus is 11 mm. above the suture at the base of the chamber, the groove outlining the base of the faint dorso-lateral lobe of the aperture being 17.5 mm. above this suture. Originally the maximum height of the camera may have been 18.5 or 10 mm. above this suture.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 241, in the Savage collection; holotype.

105. **Stenogomphoceras gracile** Sp. nov.

Plate XXIV, figs. 8 A, B

Specimen consisting of a living chamber with 4 camerae still attached. It is small and slender, but the shortness of the upper-

most camera suggests that the conch was mature. The lateral diameter at the base of the living chamber is 10 mm. and its dorso-ventral diameter is 12.5 mm. From this it enlarges to corresponding diameters of 11 mm. and 13 mm. at a point 4.5 mm. above the lowest part of the lateral lobe of the suture at the base of the specimen, narrowing thence toward the aperture. There is a faint transverse constriction about 9 mm. above the suture mentioned. The total height of the chamber was at least 16 mm. and may have equalled 17.5 mm. The lateral lobe of the suture at the base of the chamber curves downward 1 mm. The ventral saddles of the sutures tend to be slightly more angulate than the dorsal ones. Nothing of importance is known about the aperture beyond the fact that its ventral side was located on the right side of the figure as oriented.

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. No. 81452, in the U. S. National Museum; holotype.

106. **Stenogomphoceras** sp. (phragmacones)

Plate XXIII, figs. 1 A, B; 2 A, B; 4 A, B; plate XXIV, figs. 7 A, B, C

While a number of phragmacones found at Port Byron evidently belong to *Stenogomphoceras,* it has been found difficult or impossible to identify them definitely with particular species. In the specimen represented by figs. 1 A, B, on plate XXIII, that part of the living chamber which remains suggests *Stenogomphoceras chadwicki.* The specimen represented by figs. 2 A, B, on the same plate, may belong to *Stenogomphoceras inflatum.* That represented by figs. 4 A, B on this plate may belong to *Stenogomphoceras contractum.* And that represented by figs. 7 A, B, C, on plate XXIV, probably belongs to *Stenogomphoceras inflatum.*

Occurrence.—Port Byron, Illinois; in the Port Byron dolomite. In the order here cited these specimens are numbered 81455 in the U. S. National Museum; S-120 in the Savage collection; S-242 in the Savage collection; and 81452-a in the U. S. National Museum.

107. Conchs with decurrent sutures of septa

Plate V, fig. 3; pl. XI, fig. 2 A, pl. XVIII, figs. 4, 5; pl. XXI, fig. 7

Conchs with decurrent sutures of septa are not uncommon. Those figured in the present publication include specimens of *Cyrtorizoceras unguicurvatum, Amphicyrtoceras depressum, Phragmoceras wortheni,* and an unknown species of *Phragmoceras,* all from the Port Byron area. Usually the downward flexures of the sutures are narrow and occur in a vertical series. Sometimes this series continues as far as the living chamber. At other times, they are replaced at higher levels by normal sutures. Those of considerable width are far less common. The more narrow ones sometimes locate points at which the septa curve abruptly downward like funnels. Apparently successive septa were forced to envelope the base of some more or less vertical object located in contact with, or almost in contact with the inner wall of the shell.

Tentatively it is suggested that this vertical body may have been some worm-like organism living in symbiotic relationship with the cephalopod animal. In that case, the much broader downward flexures may have had a similar cause, but connected with a very different type of symbiotic animal.

In the study of *Polygrammoceras chicottense* Foerste,[16] from the Jupiter formation of Anticosti, it was noted that the interior of the conch contained a large cylindrical body almost in contact with the ventral wall, between this wall and the true siphuncle. A similar structure was figured by Blake[17] in the case of the type of *Tretoceras bisiphonatum* (Sowerby). The specific name of the latter itself is suggestive of abnormality of structure. In the Murfreesboro limestone of Tennessee there is a small cyrtoceroid which not infrequently contains a narrow tubular growth along one of the lateral sides of the conch, in addition to the normal siphuncle. In all cases so far observed these structures are close

[16] Foerste, Aug. F., in Twenhofel's Geology of Anticosti Island, Geol. Surv. Canada, mem. 154, 266, pls. 31, 32, 33 (1927).

[17] Blake, J. F., British Fossil Cephalopods, 164, pl. 16, figs. 3, 3a, 3b,4 (1882).

to the wall of the conch, though not necessarily in contact with the latter.

The object of these observations is to call attention to peculiar structures, apparently not due to mechanical injuries suffered by the shell, but to some growth within the cavity occupied by the animal itself. The causal factor giving rise to this growth is still unknown, but further studies, leading to more exact data, are desirable.

PLATE I

Fig. 1. *Centrorizoceras slocomi* Foerste. Lateral view of living chamber, with ventral outline on left. Chicago, Illinois; in the Racine. Specimen no. 4622, Walker Museum, University of Chicago; holotype.

Fig. 2. *Metarizoceras savagei* Foerste. A, ventral view; B, lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81421, U. S. National Museum; holotype.

Fig. 3. *Metarizoceras savagei* Foerste. Lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22812-A, Walker Museum, University of Chicago.

Fig. 4. *Metarizoceras robustum* Foerste. Lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-191, in the Savage collection; holotype.

Fig. 5. *Metarizoceras depauperatum* Foerste. A, dorsal view, showing slightly angulate sutures of septa; B, lateral view, with ventral outline on right. Chicago, Illinois; in the Racine. Specimen no. 22905, Walker Museum, University of Chicago; holotype.

Fig. 6. *Metarizoceras erectum* Foerste. A, lateral view, with ventral outline on left; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-190, in the Savage collection; holotype.

Fig. 7. *Metarizoceras dispandum* Foerste. Ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 1119, University of Illinois; holotype.

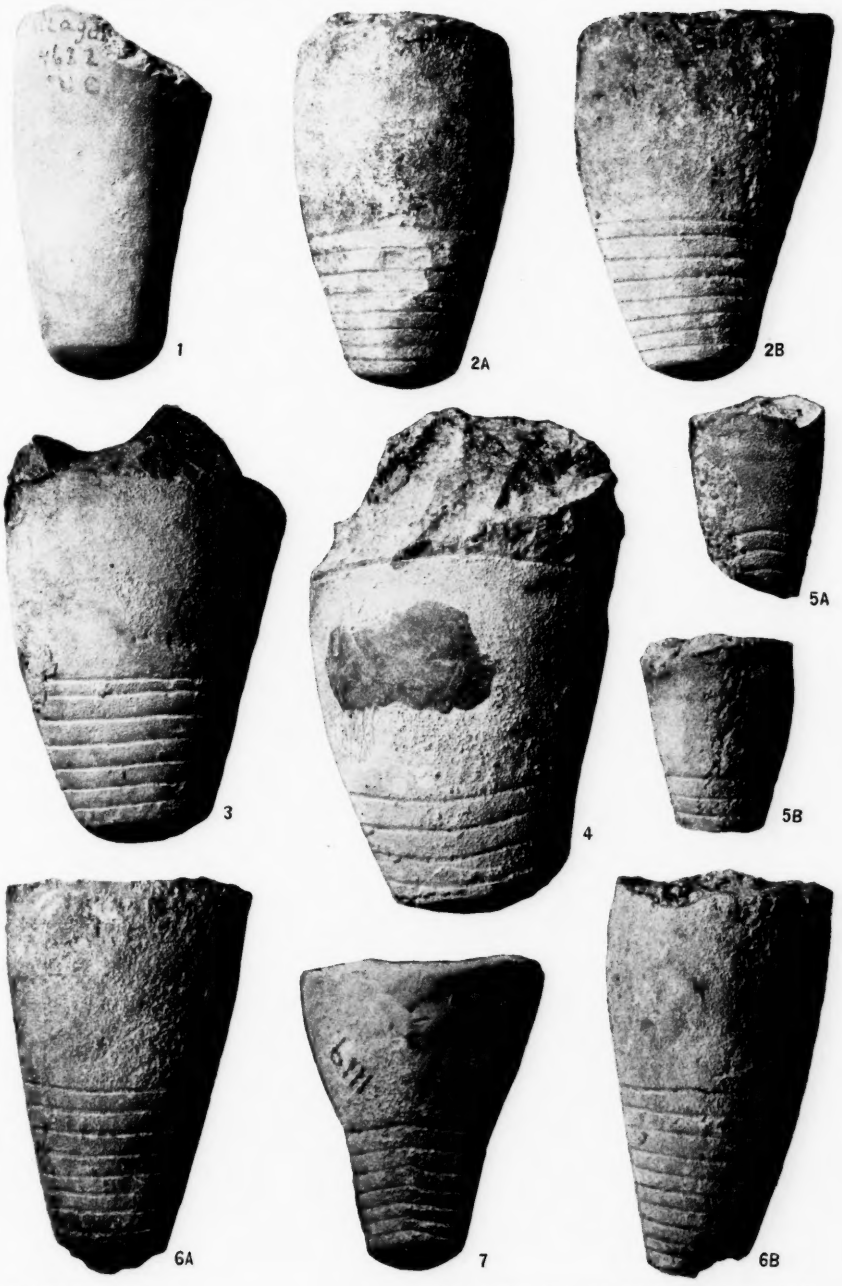

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PLATE II

Fig. 1 *Metarizoceras erectum* Foerste. A, lateral view, with ventral outline on left; B, dorsal view; C, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81422, U. S. National Museum.

Fig. 2. *Cyrtorizoceras byronense* Foerste. A, lateral view, with ventral outline on left; B, dorsal view, specimen imperfect on right; C, dorsal view, slightly oblique, with right side restored. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81424, U. S. National Museum; holotype.

Fig. 3. *Cyrtorizoceras auctidomum* Foerste. A, dorsal view, the specimen leaning forward; B, lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81425, U. S. National Museum; holotype.

Fig. 4. *Cyrtorizoceras auctidomum* Foerste. Lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81425 a, U. S. National Museum.


1A


1B


1C


2A


2B


2C


3A


3B


4

PLATE III

Fig. 1. *Cyrtorizoceras fosteri* (Hall). A, ventral view, showing the obscure annulations which curve downward ventrally; B, lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81423, in the U. S. National Museum.

Fig. 2. *Cyrtorizoceras fultonense* (Meek and Worthen). A, lateral view, with ventral outline on right; B, ventral view. Fulton City, 16 miles north of Port Byron, Illinois; in the upper Niagaran. Specimen no. 11728, University of Illinois; holotype.

Fig. 3. *Cyrtorizoceras halli* Foerste. Lateral view, with ventral outline on right. Wauwatosa, Wisconsin; in the Racine. Specimen no. 2122-B, American Museum of Natural History; holotype.

Fig. 4. *Cyrtorizoceras dardanum* (Hall). Lateral view, with ventral outline on right. Wauwatosa, Wisconsin; in the Racine. Specimen no. 2122-A, American Museum of Natural History; holotype.

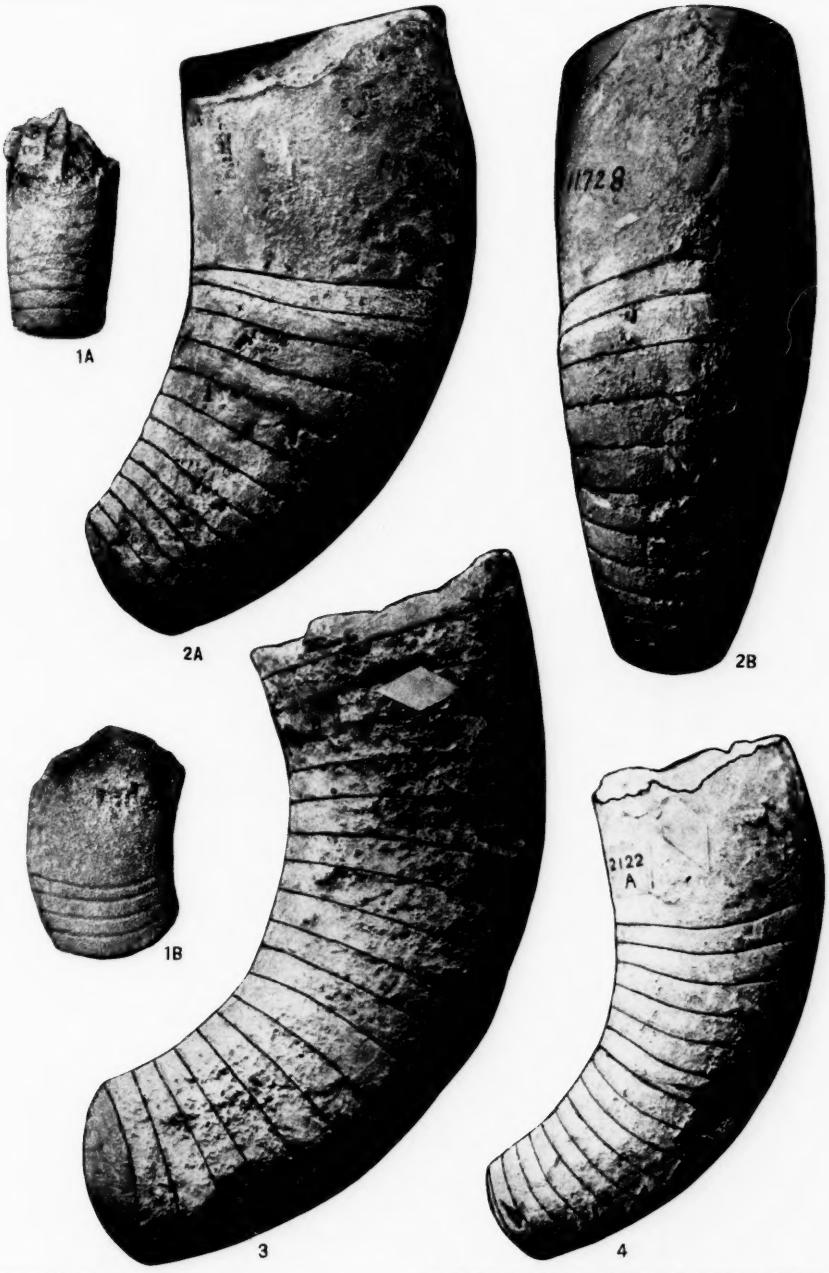

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PLATE IV

Fig. 1. *Cyrtorizoceras longidomum* Foerste. A, lateral view, with ventral outline on left; B, dorsal view, with right side missing. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81426, U. S. National Museum; holotype.

Fig. 2. *Cyrtorizoceras ruedemanni* Foerste. A, lateral view, with ventral outline on left; B, lateral view of another specimen, with same orientation. Port Byron, Illinois; in the Port Byron dolomite. Specimens no. S-192-A, and S-192-B, in the Savage collection; cotypes.

Fig. 3. *Cyrtorizoceras fosteri* (Hall). Lateral view with ventral outline on right. Moodie quarry, in southeastern part of Wilmington, Ohio; in the Cedarville dolomite. Specimen in the collection of Dr. G. M. Austin in the U. S. National Museum.

Fig. 4. *Cyrtorizoceras fosteri* (Hall). Lateral view, with ventral outline on right. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. Austin collection, in U. S. National Museum.

Fig. 5. *Cyrtorizoceras ruedemanni* Foerste. Lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-194, in the Savage collection; cotype.

Fig. 6. *Cyrtorizoceras ruedemanni* Foerste. A, ventral view, showing angulation of sutures of upper septa along their median part; B, lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22896, Walker Museum, University of Chicago.

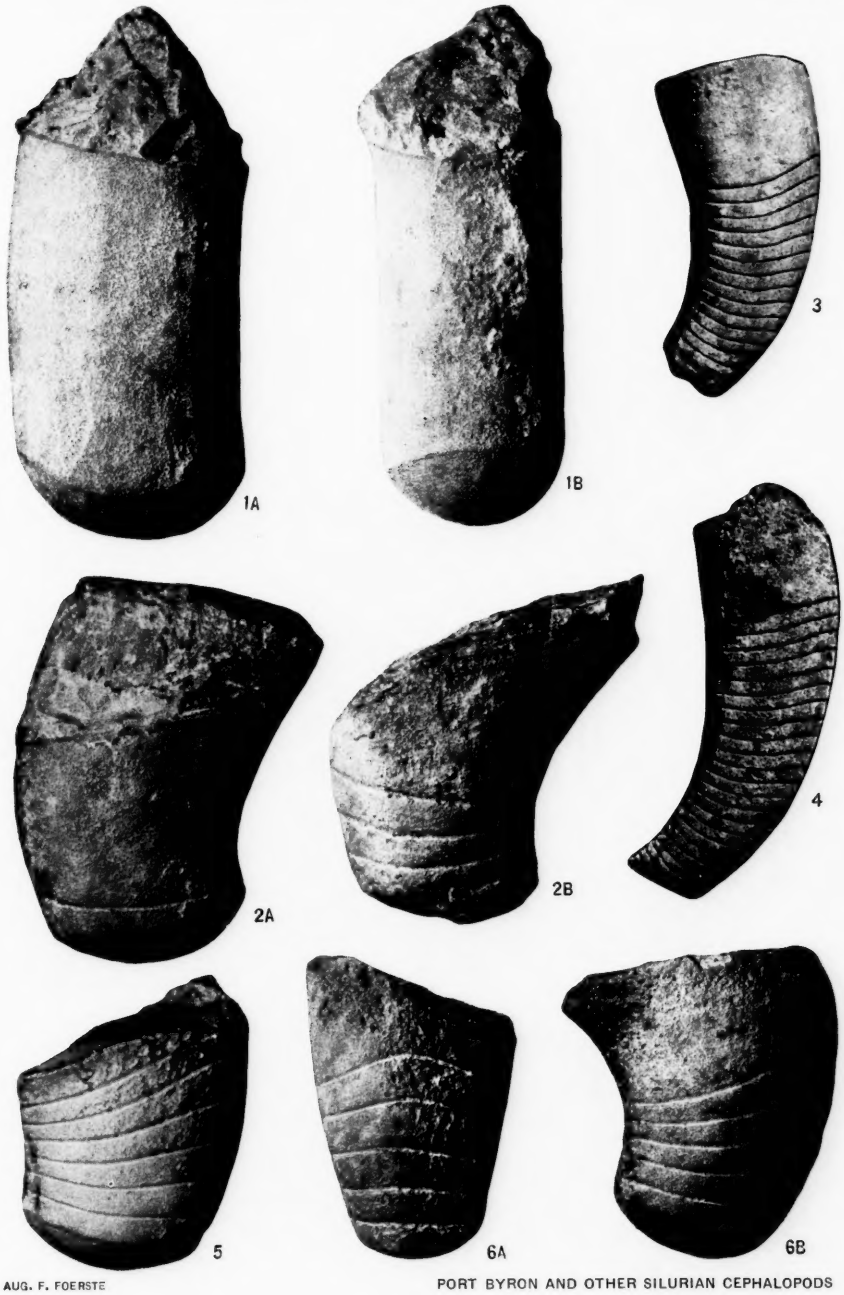

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PLATE V

Fig. 1. *Chicagooceras welleri* Foerste. A, lateral view, with ventral outline on left; B, dorsal view. Chicago, Illinois; in the Racine. Specimen no. 21891, Walker Museum, University of Chicago; holotype.

Fig. 2. *Cyrtorizoceras unguicurvatum* Foerste. Lateral view, with ventral outline on right, and with one segment of siphuncle at base. Port Byron, Illinois; in the Racine. Specimen no. S-193-B, in the Savage collection; holotype.

Fig. 3. *Cyrtorizoceras unguicurvatum* Foerste. Lateral view, oriented as preceding specimen, two of the sutures curving downward. Port Byron, Illinois; in the Racine. Specimen no. S-204, in the Savage collection.

Fig. 4. *Cyrtorizoceras unguicurvatum* Foerste. Lateral view, with ventral outline on left. Port Byron, Illinois; in the Racine. Specimen no. S-193-A, in the Savage collection.

Fig. 5. *Clionyssiceras petilum* Foerste. A, lateral view, with ventral outline on right, the septa rising in a ventrad direction, instead of sloping downward as in *Chicagooceras*; B, dorsal view. Port Byron, Illinois; in the Racine. Specimen no. 81427, U. S. National Museum; holotype.

Fig. 6. *Savageoceras transversale* Foerste. A, ventral view, specimen imperfect on left; B, lateral view, with ventral outline on left, the shell showing the surface striae. Port Byron, Illinois; in the Racine. Specimen no. S-197, in the Savage collection; holotype.

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PLATE VI

Fig. 1. *Savageoceras trapezoidale* Foerste. A, ventral view; B, lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-198, in the Savage collection; holotype.

Fig. 2. *Bickmorites welleri* Foerste. A, ventral view, specimen imperfect on the right; B, lateral view, ventral outline on right. Hawthorne, west of Chicago, Illinois; in the Racine. In the collection of the writer. Holotype.

Fig. 3. *Leurotrochoceras compressum* Foerste. A, lateral view of living chamber, with ventral outline on left; B, dorsal view, showing contact zone; C, view of base of living chamber showing location of siphuncle, and also that of the contact zone. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81428, U. S. National Museum; holotype.

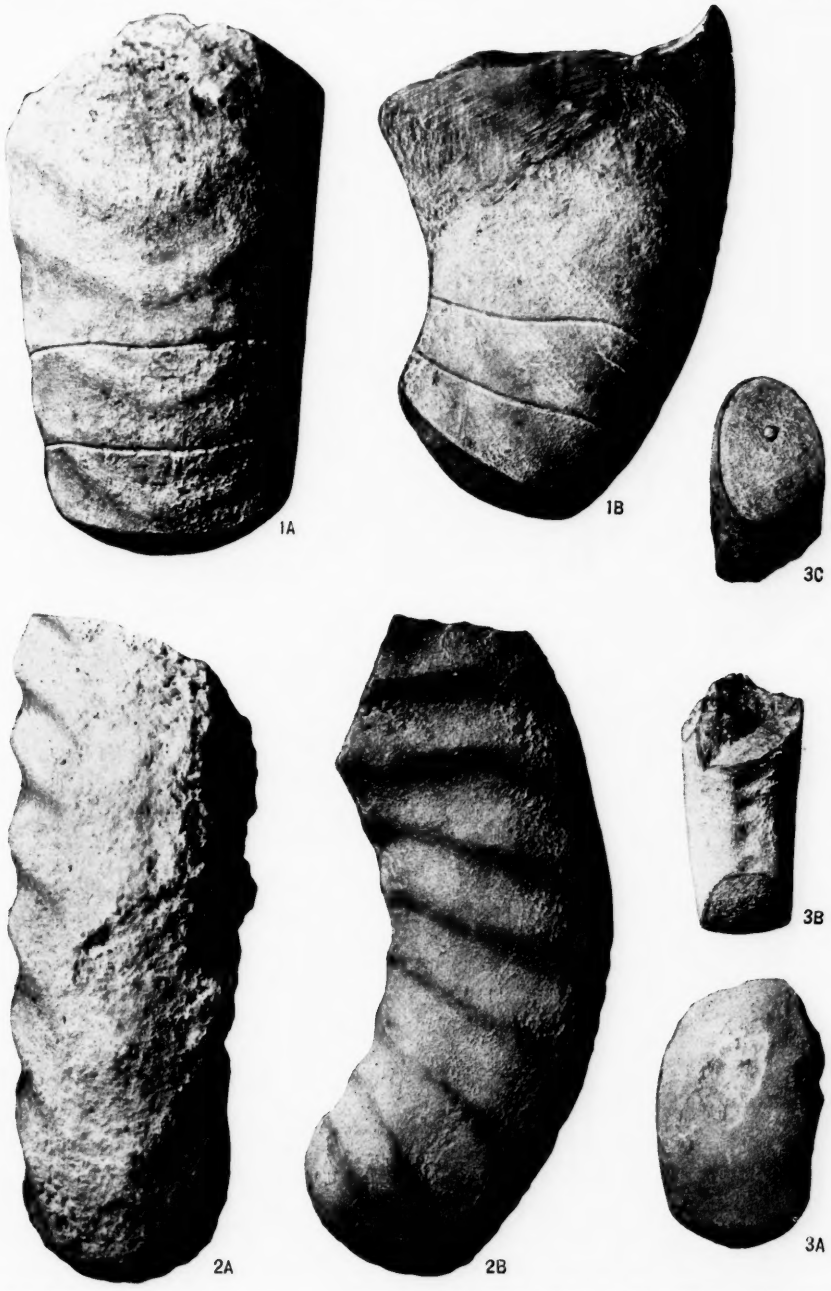

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PLATE VII

Fig. 1. *Leurotrochoceras aencas* (Hall). A, lateral view, showing the sinistral coiling; B, cross-section of conch, showing location of siphuncle. Lyons, Iowa; west of Fulton, Illinois; in the upper Niagaran. Specimen no. 2129, American Museum of Natural History; holotype.

Fig. 2. *Lechritrochoceras telleri* Foerste. A, ventral view; B, lateral view, with ventral outline on left. Chicago, Illinois; in the Racine. In the Teller collection in the U. S. National Museum; holotype.

Fig. 3. *Leurotrochoceras paucoplanatum* Foerste. A, lateral view, with ventral outline on right; B, view of septum at its base, with location of dorsal impressed zone along the upper margin of the figure. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81485, in the U. S. National Museum; holotype.

Fig. 4. *Leurotrochoceras compressum* Foerste. A, lateral view, with ventral outline on right; B, ventral view, showing traces of annulations. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81428a, in the U. S. National Museum.

Fig. 5. *Lechritrochoceras rigidum* (Hall). A, ventral view, imperfectly preserved on left; B, lateral view, the ventral side convexly curved, with a trace of the lower part of the phragmacone at *S*. Bridgeport, in the southern part of Chicago, Illinois; in the Racine. Specimen no. 2121, American Museum of Natural History; holotype.

Fig. 6. *Lechritrochoceras bannisteri* (Hall). Lateral view, with apical end of conch in contact with dorsal side of living chamber along its lower third Bridgeport, in the southern part of Chicago, Illinois; in the Racine. Specimen no. 18097-A, Walker Museum, University of Chicago; topotype.

Fig. 7. *Lechritrochoceras bannisteri* (Hall). Lateral view, with ventral outline along upper margin of figure. Bridgeport, in the southern part of Chicago, Illinois; in the Racine. Specimen no. 22940, Walker Museum, University of Chicago.

Fig. 8. *Leurotrochoceras paucoplanatum*. Foerste. A, lateral view, with ventral outline on right; B, ventral view. Port Byron, Illinois; in the Racine. Specimen no. 81485-a, in the U. S. National Museum.

Fig. 9. *Lechritrochoceras notum* (Hall). A, lateral view of actual specimen, retaining the cast of the interior of the living chamber and the impression of the exterior of the phragmacone; B, a clay impression of this specimen, showing the transverse ribs of the phragmacone better. Bridgeport, in the southern part of Chicago. Specimen no. 2162, Illinois State Museum of Natural History.

Fig-10. *"Nautilus" wilmingtonense* Foerste. Lateral view, abnormal in its coiling, the apical part of the conch being missing. Moodie quarry, in the southeastern part of Wilmington, Ohio. In the collection of Dr. L. D. Welch, deposited in Wilmington College; holotype.

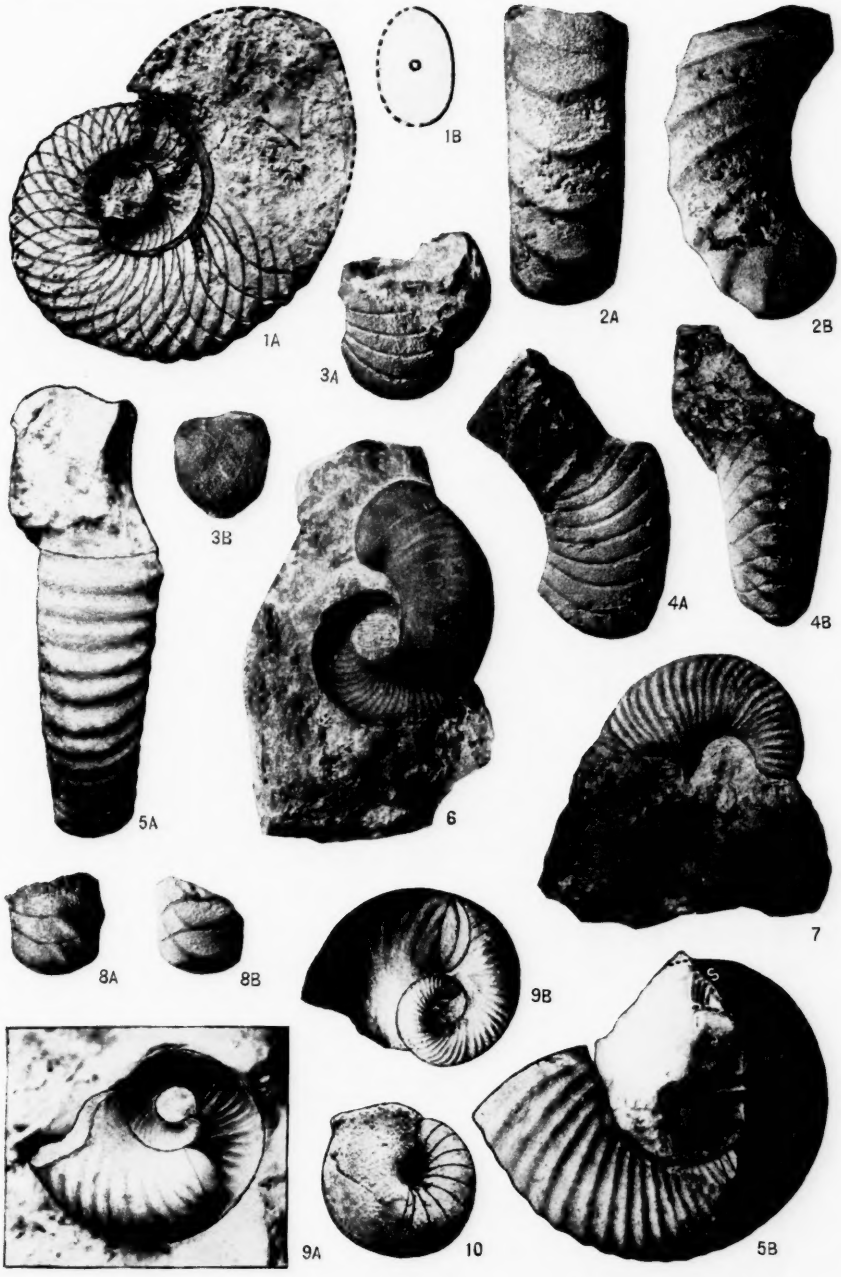
1A
1B
2A
2B
3A
3B
4A
4B
5A
6
7
8A
8B
9A
9B
10
5B

PLATE VIII

Fig. 1. *Lechritrochoceras desplainense* (McChesney). A, lateral view, as seen from upper part of spire, restored; B, lateral view of the cast of the interior of the same specimen, including the living chamber and three of the camerae. Fig. A is based chiefly on a cast of a natural impression of the exterior of the conch, but the latter does not show the distinct transverse striae shown in this figure, which is a reproduction of that published by Hall, in 20th Rep. New York State Cab. Nat. Hist., pl. 16, fig. 8 (1868). Racine, Wisconsin; in the Racine. Specimen no. 2126, American Museum of Natural History; topotype.

Fig. 2. *Ascoceras southwelli* Worthen. Lateral view, with ventral outline on left. Port Byron, Illinois, in the Port Byron dolomite. Specimen no. 2588, Illinois State Museum of Natural History; holotype.

Fig. 3. *Cyrtorizoceras fosteri* (Hall). Ventral view. Bridgeport, in the southern part of Chicago, Illinois; in the Racine. Specimen no. 2123, American Museum of Natural History; holotype.

Fig. 4. *Lechritrochoceras notum* (Hall). A, lateral view, with ventral outline on left; B, ventral view. Hawthorne, west of Chicago, Illinois, in the Racine. Specimen in the collection of the writer.

Fig. 5. *Sactoceras depressum* Foerste. A, dorsal view; B, lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-199-A, in the Savage collection.

Fig. 6. *Sactoceras depressum* Foerste. A, ventral view; B, lateral view, with ventral outline on left; both show one segment of the siphuncle at the base. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81429, U. S. National Museum; holotype.

Fig. 7. *Sactoceras depressum* Foerste. A, dorsal view; B, lateral view, with ventral outline on right; both showing living chamber with two camerae attached, apparently at gerontic stage of growth. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-199-B, in the Savage collection.

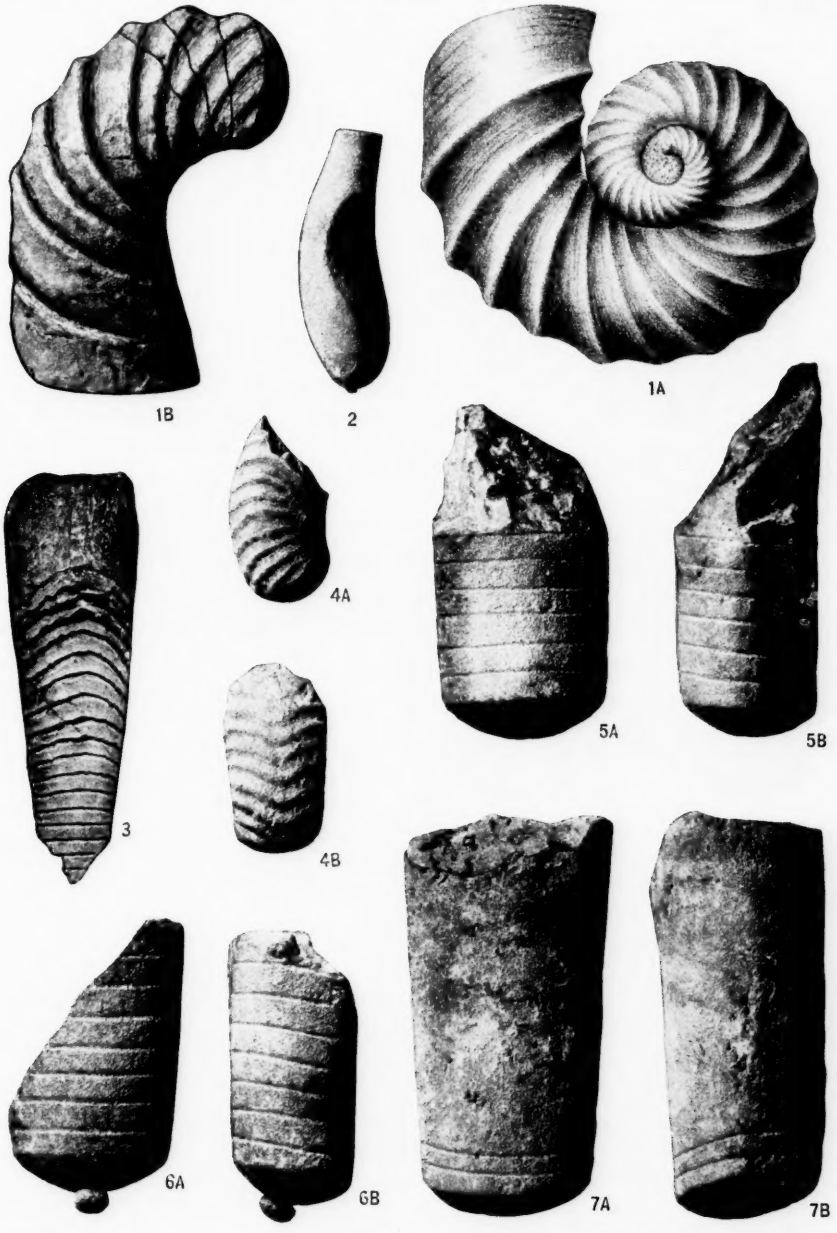

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PLATE IX

Fig. 1. *Amphicyrtoceras longidomum* Foerste. A, ventral view; B, lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22898-A, Walker Museum, University of Chicago; holotype.

Fig. 2. *Ectocyrtoceras marginatum* Foerste. A, dorsal view; B, lateral view, with ventral outline on left; C, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81437, U. S. National Museum; holotype.

Fig. 3. *Amphicyrtoceras savagei* Foerste. A, lateral view, with ventral outline on right; B, ventral view, with faint traces of vertical ribbing. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-211-A, in the Savage collection; holotype.

Fig. 4. *Ectocyrtoceras slocomi* Foerste. A, lateral view, with ventral outline on left; B, ventral view, specimen imperfect on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 21797-A, Walker Museum, University of Chicago; holotype.

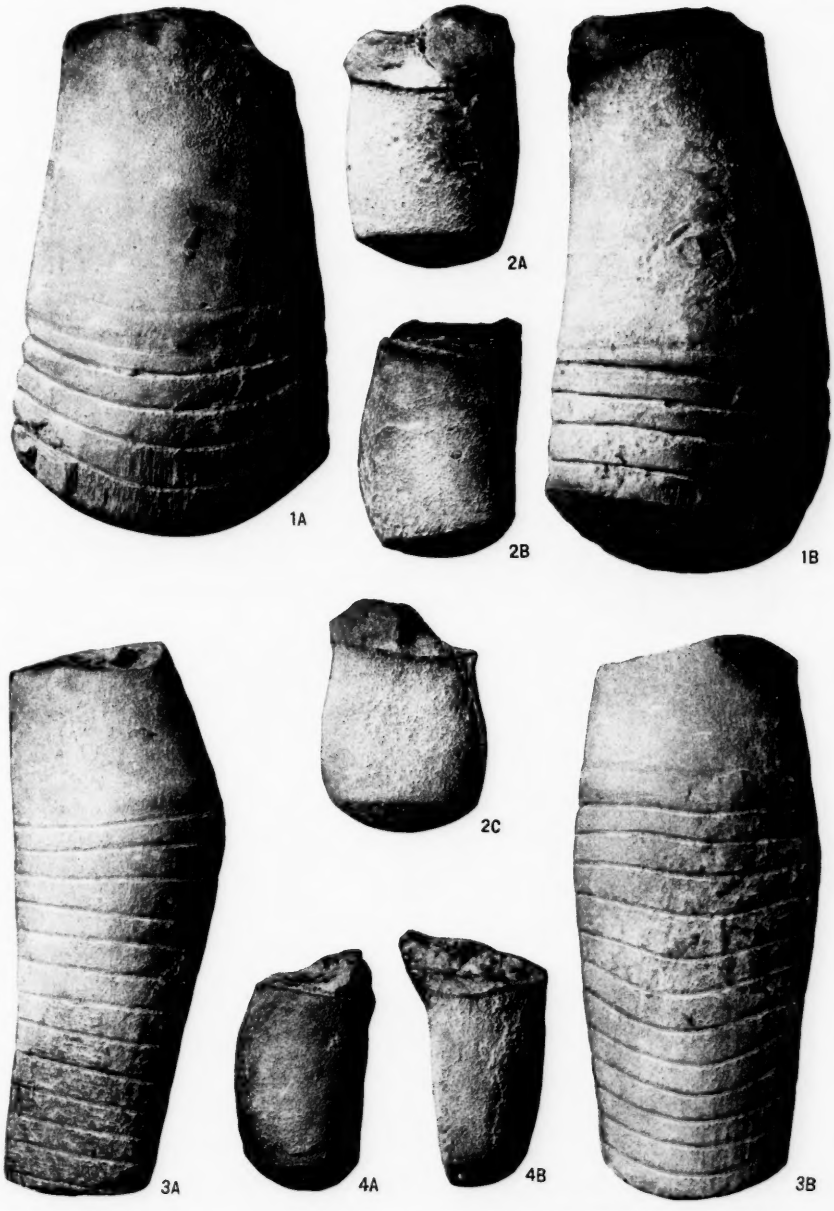

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PLATE X

Fig. 1. *Amphicyrtoceras simulans* Foerste. A, lateral view, with ventral side on left; B, dorsal view; C, view of septum at base of living chamber, with ventral margin along upper side of figure, showing location of siphuncle. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-212, in the Savage collection; holotype.

Fig. 2. *Amphicyrtoceras subcentrale* Foerste. A, dorsal view; B, lateral view, with ventral outline on left; C, view of septum at base of living chamber, with ventral outline along upper margin of figure, showing the location of the siphuncle. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22898-B, in Walker Museum, University of Chicago; holotype.

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PLATE XI

Fig. 1. *Amphicyrtoceras occidentale* Foerste. A, ventral view; B, lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-213-A, in the Savage collection; holotype.

Fig. 2. *Amphicyrtoceras depressum* Foerste. A, lateral view, with ventral outline on right, several of the sutures of the septa curving downward in an abnormal manner; B, dorsal view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22817-C, in Walker Museum, University of Chicago.

Fig. 3. *Amphicyrtoceras brevidomum* Foerste. A, ventral view; B, lateral view, with ventral outline on left. Port Byron; in the Port Byron dolomite. Specimen no. S-214-A, in the Savage collection; holotype.

Fig. 4. *Amphicyrtoceras occidentale* Foerste. Lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-213-B, Savage collection.

Fig. 5. *Eurycizoceras plenum* Foerste. A, ventral view; B, lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81440, in the U. S. National Museum.

1A

1B

2A

3A

3B

4

5A

5B

2B

PLATE XII

Fig. 1. *Amphicyrtoceras inflatum* Foerste. A, lateral view, with ventral outline on left; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81430, in the U. S. National Museum; holotype.

Fig. 2. *Amphicyrtoceras fusiforme* Foerste. A, ventral view; B, lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22817-A, Walker Museum, University of Chicago; holotype.

Fig. 3. *Amphicyrtoceras minimum* Foerste. A, ventral view, showing location of siphuncle: B, lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81432, U. S. National Museum; holotype.

Fig. 4. *Amphicyrtoceras depressum* Foerste. A, dorsal view; B, lateral view, with ventral outline on right, showing one segment of the siphuncle at its base. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-217-A, in the Savage collection; holotype.

Fig. 5. *Amphicyrtoceras depressum* Foerste. A, dorsal view; B, lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-188, Savage collection.

Fig. 6. *Worthenoceras crooki* Foerste. A, dorsal view; B, lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-217-B, in the Savage collection; holotype.

Fig. 7. *Amphicyrtoceras depressum* Foerste. A, lateral view, with ventral outline on left; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81431, in the U. S. National Museum.

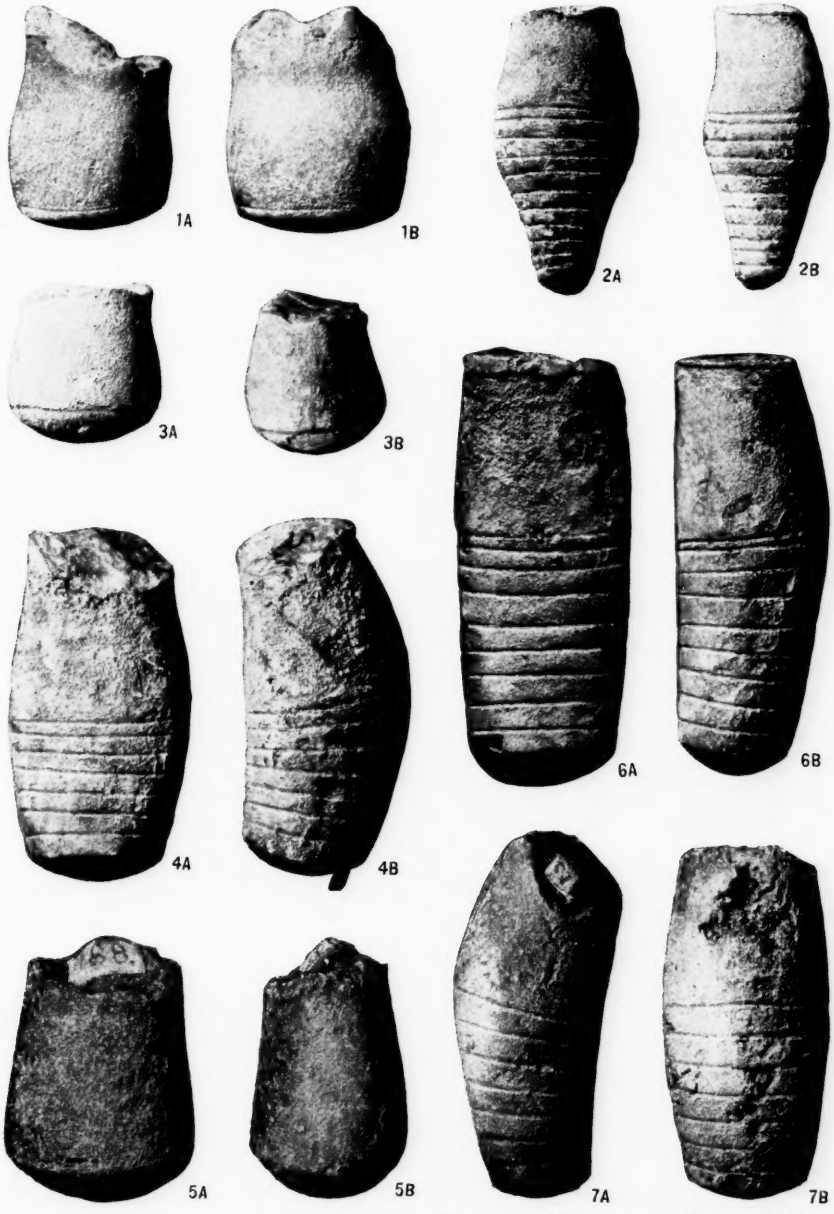

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PLATE XIII

Fig. 1. *Worthenoceras curtum* Foerste. A, lateral view, with ventral outline on left; B, ventral view; C, dorsal view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81436, in the U. S. National Museum; holotype.

Fig. 2. *Worthenoceras byronense* Foerste. A, lateral view, with ventral outline on left; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-316-B, in the Savage collection; holotype.

Fig. 3. *Worthenoceras byronense* Foerste. A, lateral view, with ventral outline on right; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-316-A, in the Savage collection.

Fig. 4. *Worthenoceras exiguum* Foerste. A, ventral view; B, lateral view, with ventral outline on left, showing trace of siphuncle at its base. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81435, in the U. S. National Museum; holotype.

Fig. 5. *Amphicyrtoceras unguliforme* Foerste. A, dorsal view; B, lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22817-B, Walker Museum, University of Chicago; holotype.

Fig. 6. *Worthenoceras elongatum* Foerste. A, lateral view, with ventral outline on left; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-216-C, in the Savage collection; holotype.

Fig. 7. *Worthenoceras elongatum* Foerste. A, lateral view, with ventral outline on right; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81433, in the U. S. National Museum.

Fig. 8. *Worthenoceras elongatum* Foerste. A, lateral view, with ventral outline on right; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81433-a, in the U. S. National Museum.

Fig. 9. *Gonatocyrtoceras inflatum* Foerste. A, ventral view; B, lateral view, with ventral outline on right. Joliet, Illinois; in the Joliet member of the Niagaran. Specimen no. 22919, Walker Museum; University of Chicago.

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PLATE XIV

Fig. 1. *Eurytizoceras chadwicki* Foerste. A, lateral view, with ventral outline on left; B, ventral view. Specimen no. S-218-A, in the Savage collection; holotype.

Fig. 2. *Eurytizoceras chadwicki* Foerste. A, dorsal view; B, lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81438, U. S. National Museum.

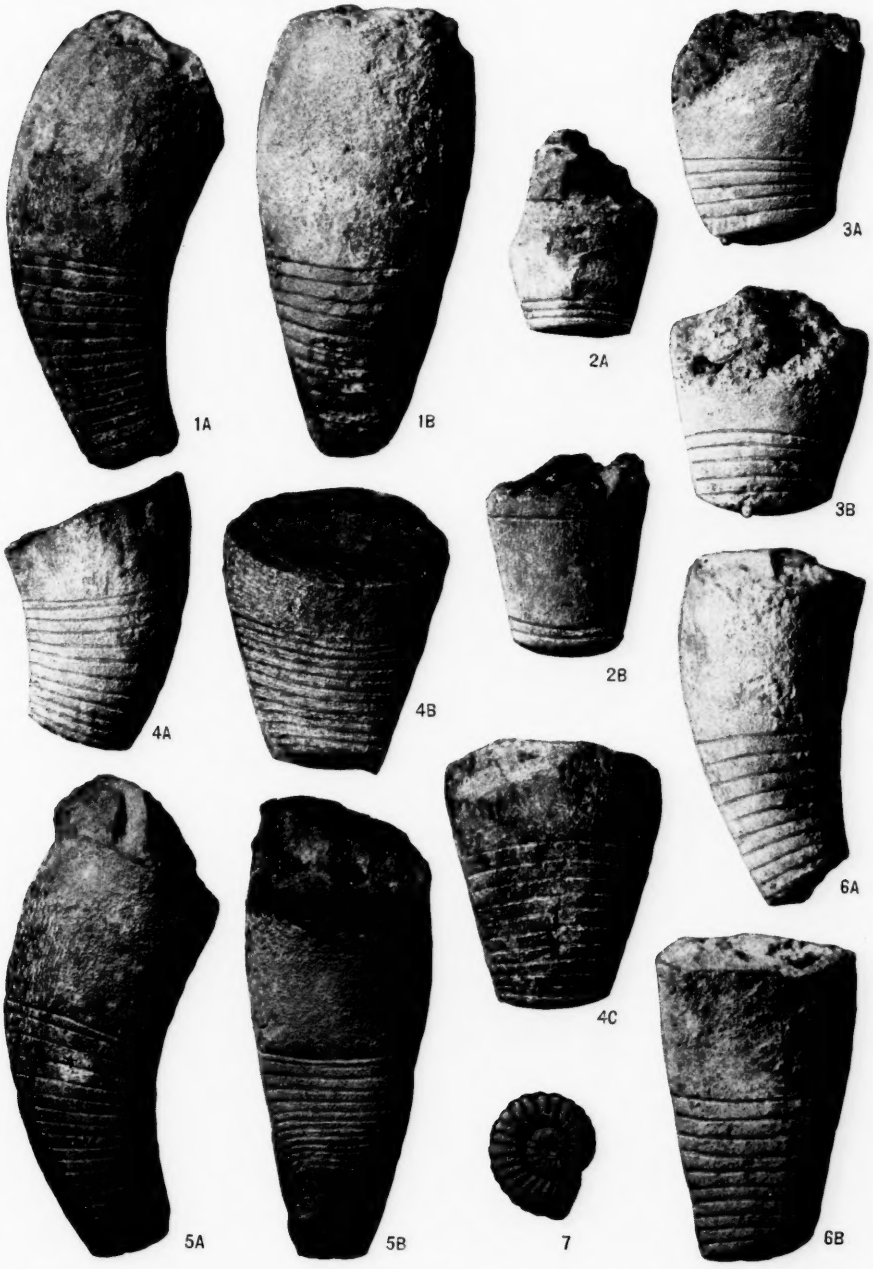
Fig. 3. *Eurytizoceras chadwicki* Foerste. A, lateral view, with ventral outline on left; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81438-a, U. S. National Museum.

Fig. 4. *Eurytizoceras chadwicki* Foerste. A, lateral view, with ventral outline on right; B, dorsal view; C, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81438-b, U. S. National Museum.

Fig. 5. *Eurytizoceras clinoseptatum* Foerste. A, lateral view, with ventral outline on left; B, dorsal view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81439, U. S. National Museum; holotype.

Fig. 6. *Eurytizoceras dispar* Foerste. A, lateral view, with ventral outline on left; B, dorsal view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-219, in the Savage collection; holotype.

Fig. 7. *Ophidioceras wilmingtonense* Foerste. Lateral view of conch. Moodie quarry, in southeastern part of Wilmington, Ohio; in the Cedarville dolomite. Second specimen described in Jour. Sci. Lab., Denison Univ. 21, 66 (1925), but not figured in that publication. In the Austin Collection, in the U. S. National Museum.



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PORT BYRON AND OTHER SILURIAN CEPHALOPODS

PLATE XV

Fig. 1. *Slocomoceras retrorsum* Foerste. A, ventral view; B, lateral view with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81442, in the U. S. National Museum; holotype.

Fig. 2. *Slocomoceras retrorsum* Foerste. A, ventral view, showing downward curvature of suture of septum, and also one segment of the siphuncle; B, lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81442-a, in the U. S. National Museum.

Fig. 3. *Slocomoceras retrorsum* Foerste. A, ventral view; B, lateral view, with ventral outline on left; C, dorsal view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81442-b, in the U. S. National Museum.

Fig. 4. *Slocomoceras retrorsum* Foerste. Lateral view, with ventral outline on right, showing the segments of the siphuncle. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81442-c, in the U. S. National Museum.

Fig. 5. *Slocomoceras retrorsum* Foerste. Ventral view, showing siphuncle. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81442-d, in the U. S. National Museum.

Fig. 6. *Euryrizoceras* cf. *percurvatum* Foerste. A, lateral view, with ventral outline on right; B, ventral view, with siphuncle exposed by slight weathering of cast of interior of conch. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81441, in the U. S. National Museum.


1A


1B


4


6A


5


2A


2B


6B


3A


3B


3C

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PLATE XVI

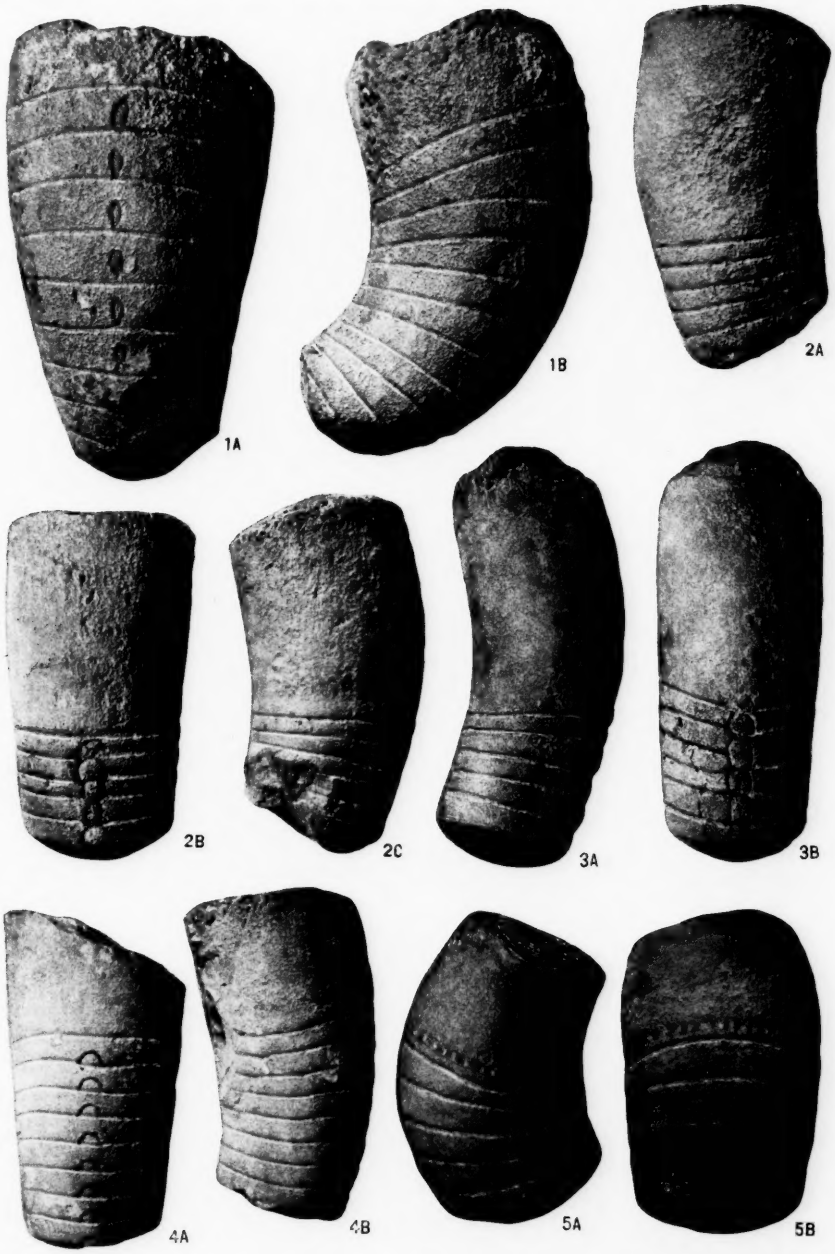
Fig. 1. *Euryrizoceras percurvatum* Foerste. A, ventral view, with siphuncle partially exposed by weathering of cast of interior; B, lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22818, Walker Museum, University of Chicago; holotype.

Fig. 2. *Byronoceras transversale* Foerste. A, lateral view, with ventral outline on left; B, ventral view, with siphuncle partially exposed by weathering; C, lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81444, in the U. S. National Museum; holotype.

Fig. 3. *Byronoceras longidomum* Foerste. A, lateral view, with ventral outline on right; B, ventral view, with siphuncle exposed. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81443, in the U. S. National Museum; holotype.

Fig. 4. *Byronoceras commune* Foerste. A, ventral view, with siphuncle partially exposed; B, lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81445, in the U. S. National Museum; holotype.

Fig. 5. *Anomeioceras vicinum* Foerste. A, lateral view, with ventral outline on left; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-224, in the Savage collection.



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PORT BYRON AND OTHER SILURIAN CEPHALOPODS

PLATE XVII

Fig. 1. *Perioidanoceras rotundum* Foerste. A, dorsal view; B, lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-195, in the Savage collection; holotype.

Fig. 2. *Byronoceras paulocurvatum* Foerste. A, dorsal view; B, lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22893, Walker Museum, University of Chicago; holotype.

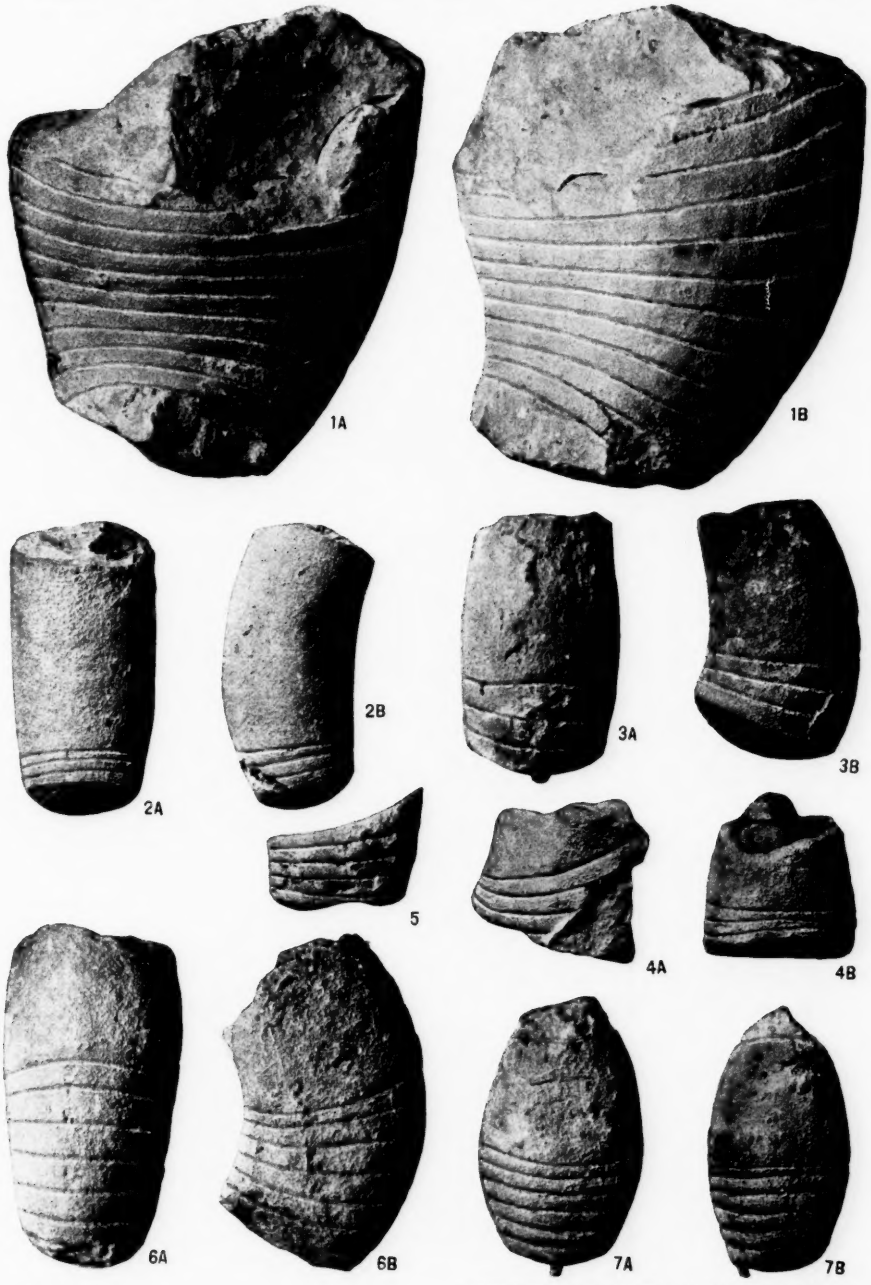
Fig. 3. *Anomeioceras savagei* Foerste. A, ventral view, showing trace of segment of siphuncle at its base. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-196, in the Savage collection.

Fig. 4. *Anomeioceras brevicameratum* Foerste. A, lateral view, with ventral side on right; B, dorsal view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81447, in the U. S. National Museum; holotype.

Fig. 5. *Anomeioceras brevicameratum* Foerste. Lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81447-a, in the U. S. National Museum.

Fig. 6. *Anomeioceras compressum* Foerste. A, ventral view; B, lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81446, in the U. S. National Museum.

Fig. 7. *Chadwickoceras ellipticum* Foerste. A, ventral view, with segment of siphuncle at its base; B, lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-222, in the Savage collection.



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PORT BYRON AND OTHER SILURIAN CEPHALOPODS

PLATE XVIII

Fig. 1. *Chadwickoceras fusiforme* Foerste. A, dorsal view; B, lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-220-A, in the Savage collection; holotype.

Fig. 2. *Chadwickoceras erectum* Foerste. A, lateral view, with ventral outline on right; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81448, in the U. S. National Museum.

Fig. 3. *Chadwickoceras pauper* Foerste. A, dorsal view; B, lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-221, in the Savage collection; holotype.

Fig. 4. *Phragmoceras* sp. (Port Byron). Lateral view, with ventral outline on right. The sutures of the septa curve downward in an abnormal manner along the upper part of the phragmacone. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-203, in the Savage collection. Probably same species as that represented on plate XXI, by fig. 7.

Fig. 5. *Phragmoceras worthemi* Foerste. Lateral view, with ventral outline on right. Some of the sutures of the septa curving downward in an abnormal manner along the middle of this lateral side. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22924, Walker Museum, University of Chicago.

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PORT BYRON AND OTHER SILURIAN CEPHALOPODS

PLATE XIX

Fig. 1. *Phragmoceras wortheni* Foerste. Lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-201-C, in the Savage collection; holotype.

Fig. 2. *Phragmoceras wortheni* Foerste. Lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-201-A, in the Savage collection.

Fig. 3. *Phragmoceras ontarioense* Foerste. A, lateral view, with ventral outline on right, and with a segment of the siphuncle at its base; B, dorsal view, showing trilobate outline of dorsal side of dorsal expansion of the aperture. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-206-A, in the Savage collection.

Fig. 4. *Phragmoceras ontarioense* Foerste. A, lateral view, with ventral outline on left; B, dorsal view, showing trilobation of dorsal outline of aperture. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81449, in the U. S. National Museum.

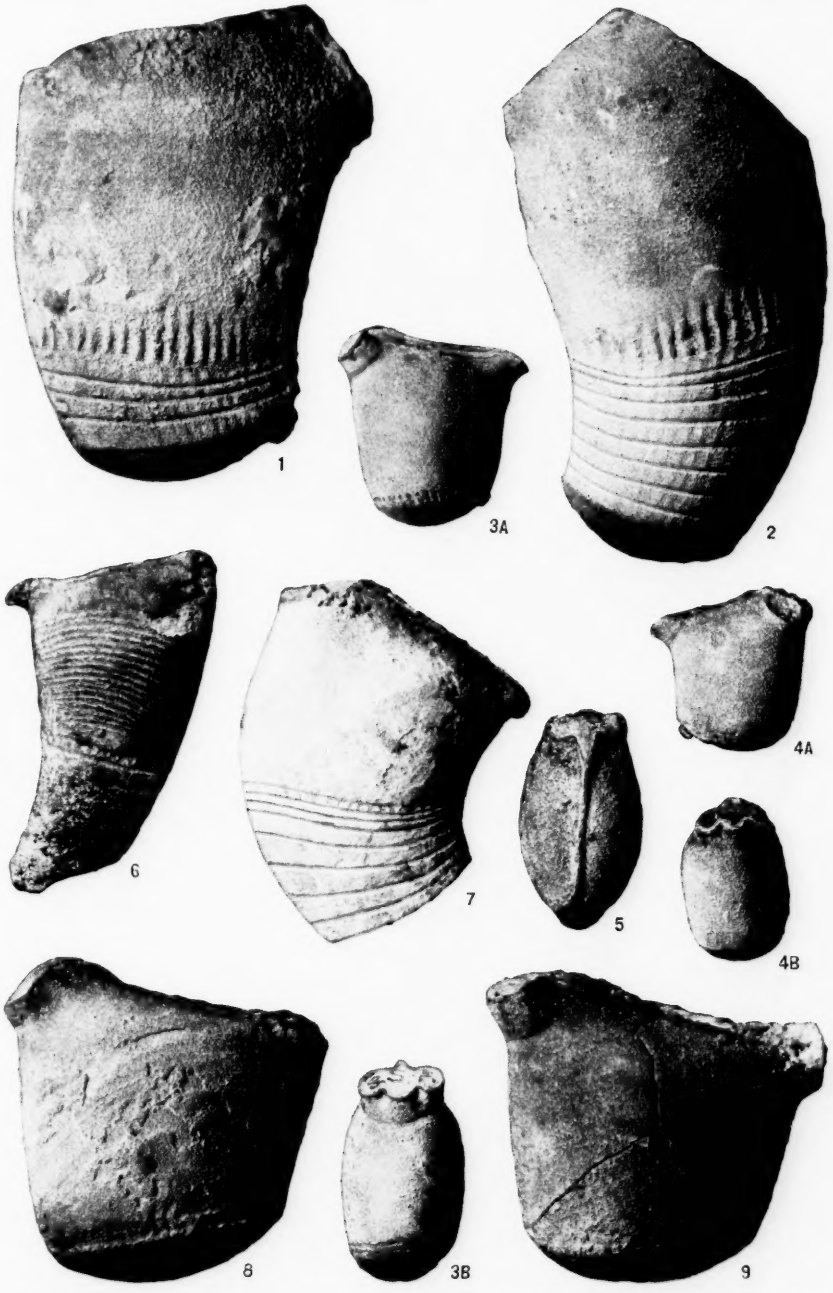
Fig. 5. *Phragmoceras ontarioense* Foerste. Living chamber viewed from above, showing the aperture; especially the indenting of the ventral side of its dorsal lobe by the backward growth of that part of the shell which borders on the dorsal end of the narrowly linear part of the aperture. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81449-a, in the U. S. National Museum.

Fig. 6. *Phragmoceras ontarioense* Foerste. Lateral view, with ventral outline on left; showing probable course of transverse striae on surface of the shell, judging from faint markings on cast of its interior. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 1122, University of Illinois.

Fig. 7. *Phragmoceras arcanum* Foerste. Lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-205, in the Savage collection; holotype.

Fig. 8. *Phragmoceras chicagoense* Foerste. Lateral view, with ventral outline on right. Chicago, Illinois; in the Racine. Specimen no. 22922-A. Walker Museum, University of Chicago; holotype. Same specimen as Jour. Sci. Lab. Denison Univ., 24, 339, pl. 63, figs. 3 A, B (1929), but with dorso-ventral outline accurate.

Fig. 9. *Phragmoceras chicagoense* Foerste. Lateral view, with ventral outline on right. Chicago, Illinois; in the Racine. Specimen no. 22922, Walker Museum, University of Chicago. Same specimen as Jour. Sci. Lab. Denison Univ., 24, 339, pl. 63, figs. 4 A, B (1929), but with dorso-ventral outline accurate.



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PORT BYRON AND OTHER SILURIAN CEPHALOPODS

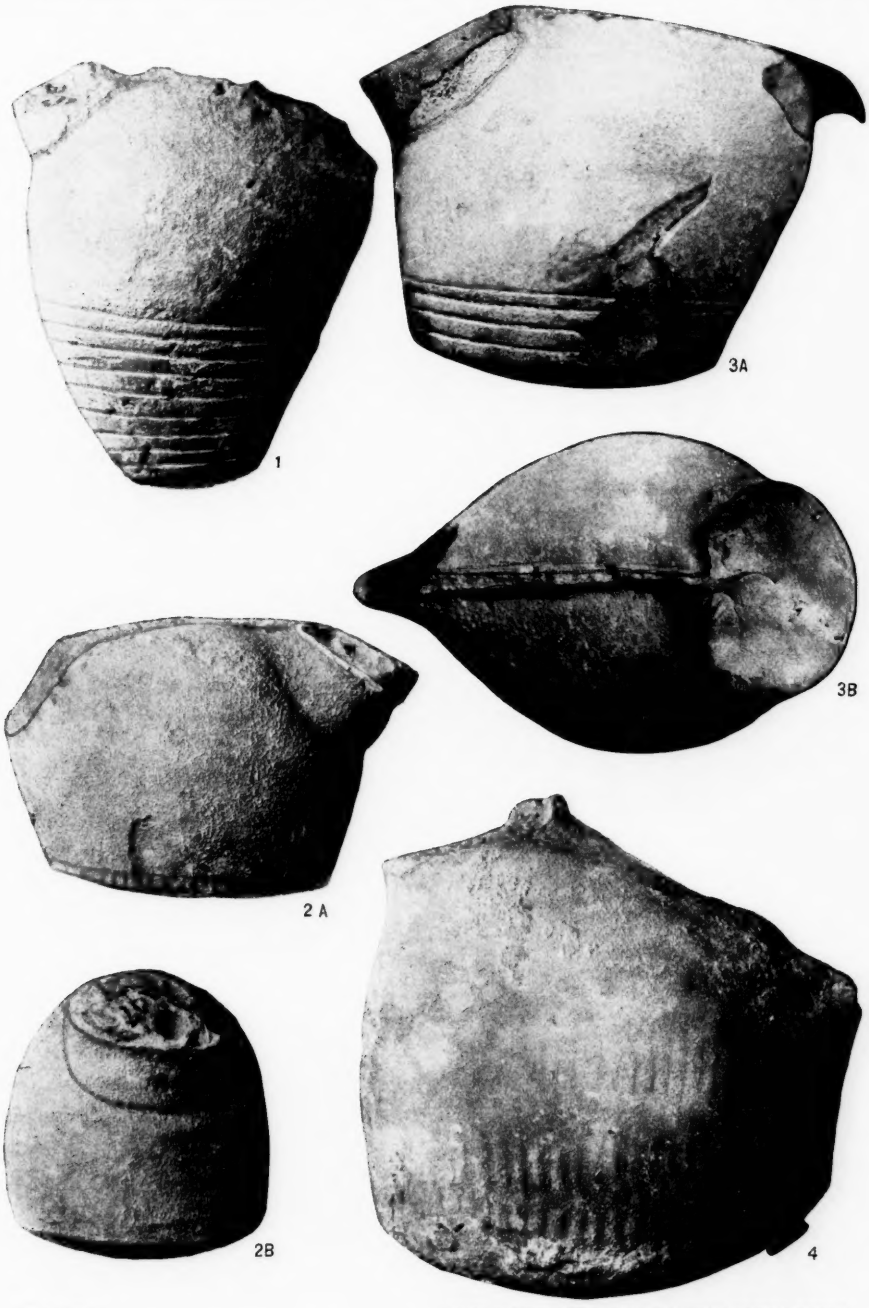
PLATE XX

Fig. 1. *Tubiferoceras savagei* Foerste. Lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-207-B, in the Savage collection; holotype.

Fig. 2. *Tubiferoceras savagei* Foerste. A, lateral view, with ventral outline on left; B, dorsal view, with groove outlining the basal part of the dorsal neck, in the cast of the interior of the living chamber. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-207-A, in the Savage collection.

Fig. 3. *Tubiferoceras savagei* Foerste. A, lateral view, with ventral outline on left, the spout-like projection at the hyponomic sinus restored; B, same specimen viewed from above, and showing the aperture. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 1142, University of Illinois.

Fig. 4. *Phragmoceras vicinum* Foerste. Lateral view, with ventral outline on right. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-200-D, in the Savage collection; holotype.



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PORT BYRON AND OTHER SILURIAN CEPHALOPODS

PLATE XXI

Fig. 1. *Mandaloceras scrinium* (Hall). Lateral view, with ventral outline on right. Bridgeport, in the southern part of Chicago, Illinois; in the Racine. Specimen no. 25847-A, Walker Museum, University of Chicago. For additional figures of this species see Jour. Sci. Lab. Denison Univ., 24, 370, pl. 62, figs. 3 A, B, C (1929).

Fig. 2. *Mandaloceras scrinium* (Hall). Lateral view, with ventral outline on right. Chicago, Illinois; in the Racine. Specimen no. 18106-B, Walker Museum, University of Chicago. Specimen doubtfully referred to this species.

Fig. 3. *Mandaloceras marcyae* (Winchell and Marcy). Lateral view, with ventral outline on right. Chicago, Illinois; in the Racine. Only form known from the Racine which might belong to the species figured by Winchell and Marcy, but differing greatly in the outline of its aperture. Specimen no. 21895, Walker Museum, University of Chicago.

Fig. 4. *Mandaloceras hawthornense* Foerste. A, dorsal view; B, lateral view, with ventral outline on right. Hawthorne, west of Chicago, Illinois; in the Racine. Specimen no. 81450, in the U. S. National Museum.

Fig. 5. *Mandaloceras diminuens* Foerste. A, lateral view, with ventral outline on right; B, dorsal view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22816, Walker Museum, University of Chicago; holotype.

Fig. 6. *Mandalozeras hawthornense* Foerste. Ventral view. Hawthorne, west of Chicago, Illinois; in the Racine. Specimen no. 21967-B, Walker Museum, University of Chicago; holotype.

Fig. 7. *Phragmoceras* sp. (Port Byron). Lateral view, showing abnormal downward curvature of the sutures of the septa. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-202, in the Savage collection. This specimen probably belongs to the same species as that represented on plate XVIII, by figure 4.

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PLATE XXII

Fig. 1. *Hexameroceras byronense* Foerste. A, lateral view, with ventral outline on left; B, view from above, showing aperture; C, dorsal view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-209-B, in the Savage collection; holotype.

Fig. 2. *Hexamoceras byronense* Foerste. A, lateral view, with ventral outline on left; B, view from above, showing the aperture. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-209-A, in the Savage collection.

Fig. 3. *Hexameroceras depressum* Foerste. A, lateral view, with ventral outline on left; B, viewed obliquely from above, showing aperture. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 2150-D, Museum of Comparative Zoology, Harvard University; holotype.

Fig. 4. *Hexameroceras jolietense* Foerste. Lateral view, with ventral outline on left. Joliet, Illinois; in the Joliet member of the upper Niagaran. Specimen no. 22941, Walker Museum, University of Chicago.

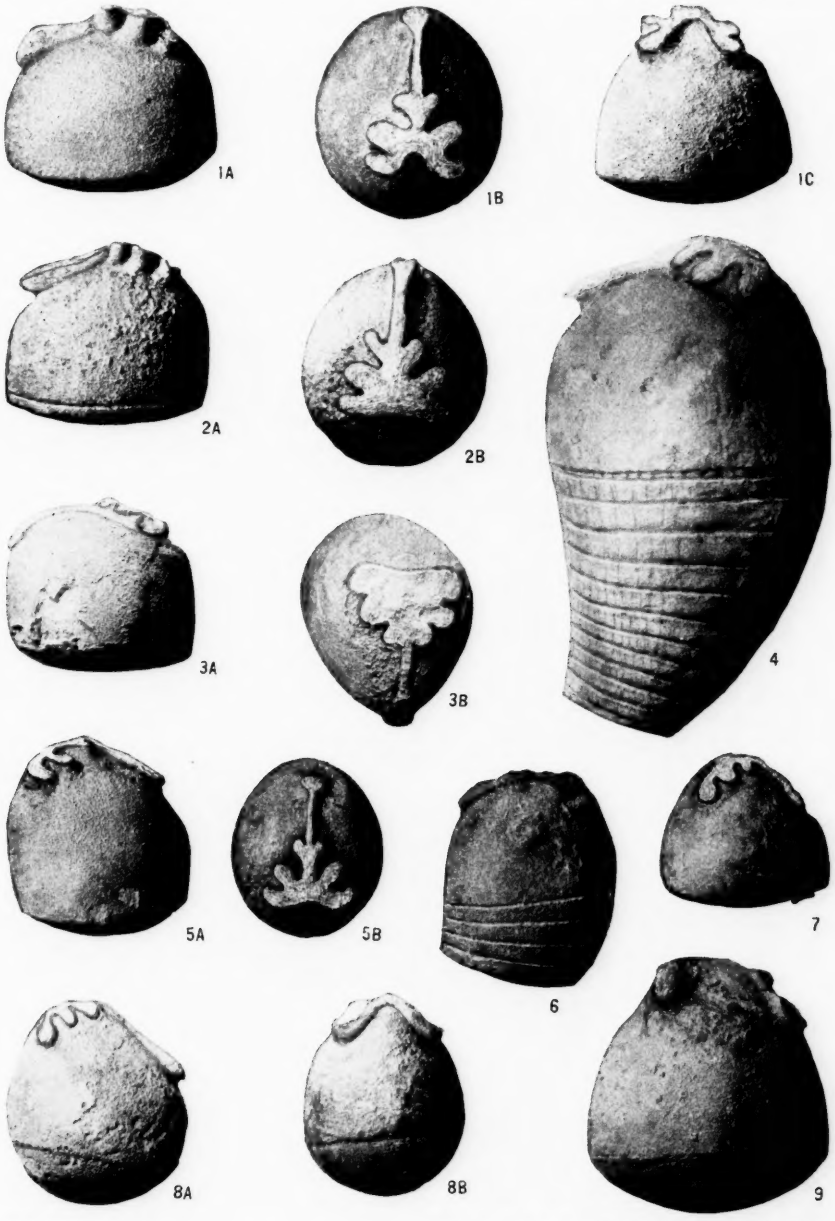
Fig. 5. *Hexameroceras arctilobatum* Foerste. A, lateral view, with ventral outline on right; B, viewed from above, showing the aperture. Wauwatosa, Wisconsin; in the Racine. Specimen no. 22813-C, Walker Museum, University of Chicago.

Fig. 6. *Hexameroceras compressum* Foerste. Lateral view, with ventral outline on left. Moodie quarry, in southeastern part of Wilmington, Ohio; in the Cedarville dolomite. Specimen no. 2159, Walker Museum, University of Chicago.

Fig. 7. *Hexameroceras septore* (Hall). Lateral view, with ventral outline on right. Wauwatosa, Wisconsin; in the Racine. Specimen no. 12649, Walker Museum, University of Chicago; holotype. For additional illustrations of this species see Jour. Sci. Lab. Denison Univ., 24, 376, pl. 62, figs. 2 A, B, C (1929).

Fig. 8. *Hexameroceras globosum* Foerste. A, lateral view, with ventral outline on right; B, dorsal view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22813-K, Walker Museum, University of Chicago.

Fig. 9. *Mandaloceras scrinium* (Hall). Lateral view, with ventral outline on right. Hawthorne, west of Chicago, Illinois; in the Racine. Specimen no. 18106-R, Walker Museum, University of Chicago.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3B
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8A
8B
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PLATE XXIII

Fig. 1. *Stenogomphoceras cf. chadwicki* Foerste. A, lateral view, with ventral outline on left; B, ventral view, showing angulation of sutures of the septa. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81455, in the U. S. National Museum.

Fig. 2. *Stenogomphoceras cf. inflatum* Foerste. A, lateral view with ventral outline on left; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-210, in the Savage collection.

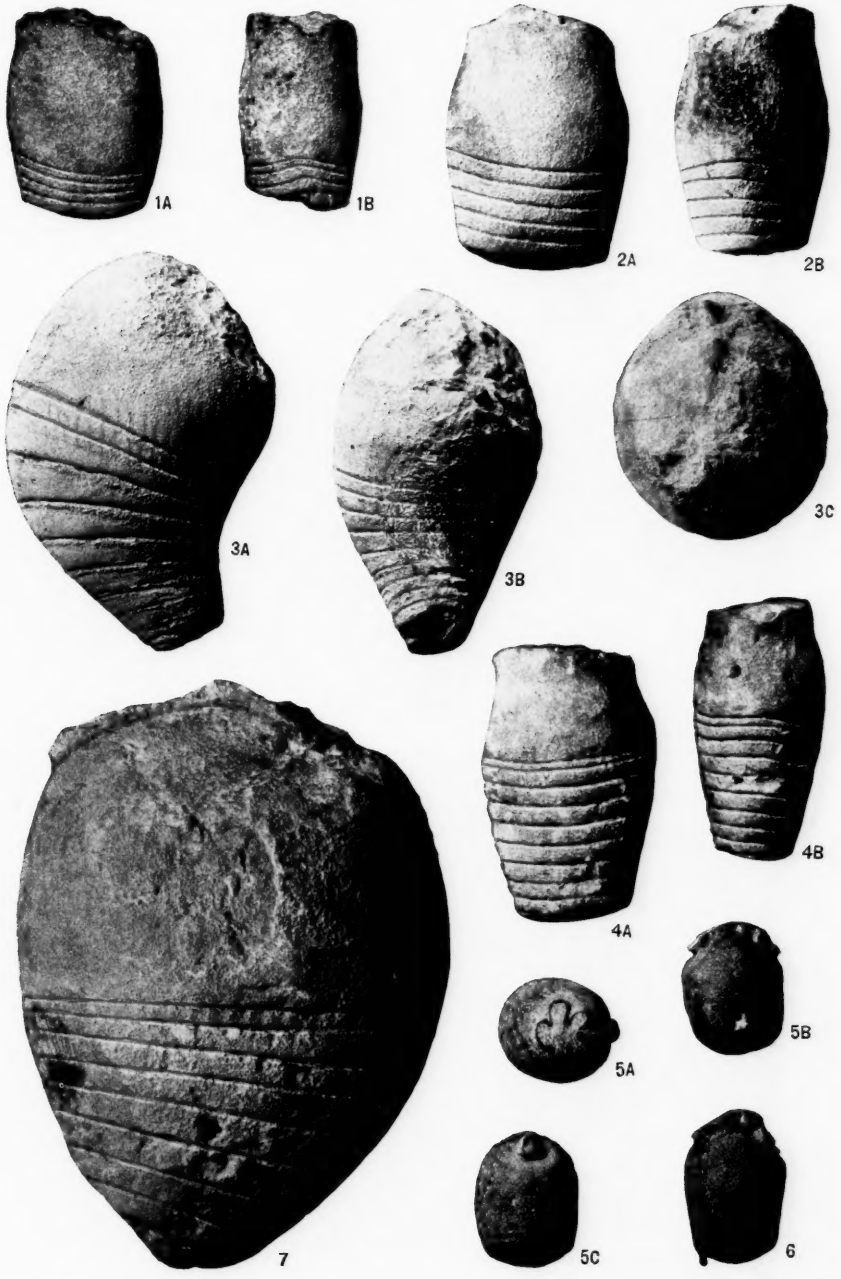
Fig. 3. *Hexamerceras cf. hertzeri* (Hall and Whitfield). A, lateral view, with ventral outline on right; B, ventral view; C, viewed from above. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 2150-B, Museum of Comparative Zoology, Harvard University.

Fig. 4. *Stenogomphoceras cf. contractum* Foerste. A, lateral view, with ventral outline on left; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-242, in the Savage collection.

Fig. 5. *Pentameroceras byronense* Foerste. A, viewed from above, showing aperture; B, lateral view, with ventral outline on left; C, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22814-B, Walker Museum, University of Chicago.

Fig. 6. *Pentameroceras byronense* Foerste. Lateral view, with ventral outline on left, and with one segment of siphuncle at its base. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 22814-A, Walker Museum, University of Chicago; holotype.

Fig. 7. *Hexameroceras* (?) *turgidum* Foerste. Lateral view, with ventral outline on left. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-208, in the Savage collection; holotype.



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PORT BYRON AND OTHER SILURIAN CEPHALOPODS

PLATE XXIV

Fig. 1. *Stenogomphoceras chadwicki* Foerste. A, lateral view, with ventral outline on right; B, ventral view; C, dorsal view; D, diagram of view from above, showing outline of aperture. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81451, in the U. S. National Museum; holotype.

Fig. 2. *Stenogomphoceras chadwicki* Foerste. A, lateral view, with ventral outline on left; B, viewed from above, showing outline of aperture. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 1117, University of Illinois.

Fig. 3. *Stenogomphoceras inflatum* Foerste. A, lateral view, with ventral outline on left; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-227, in the Savage collection; holotype.

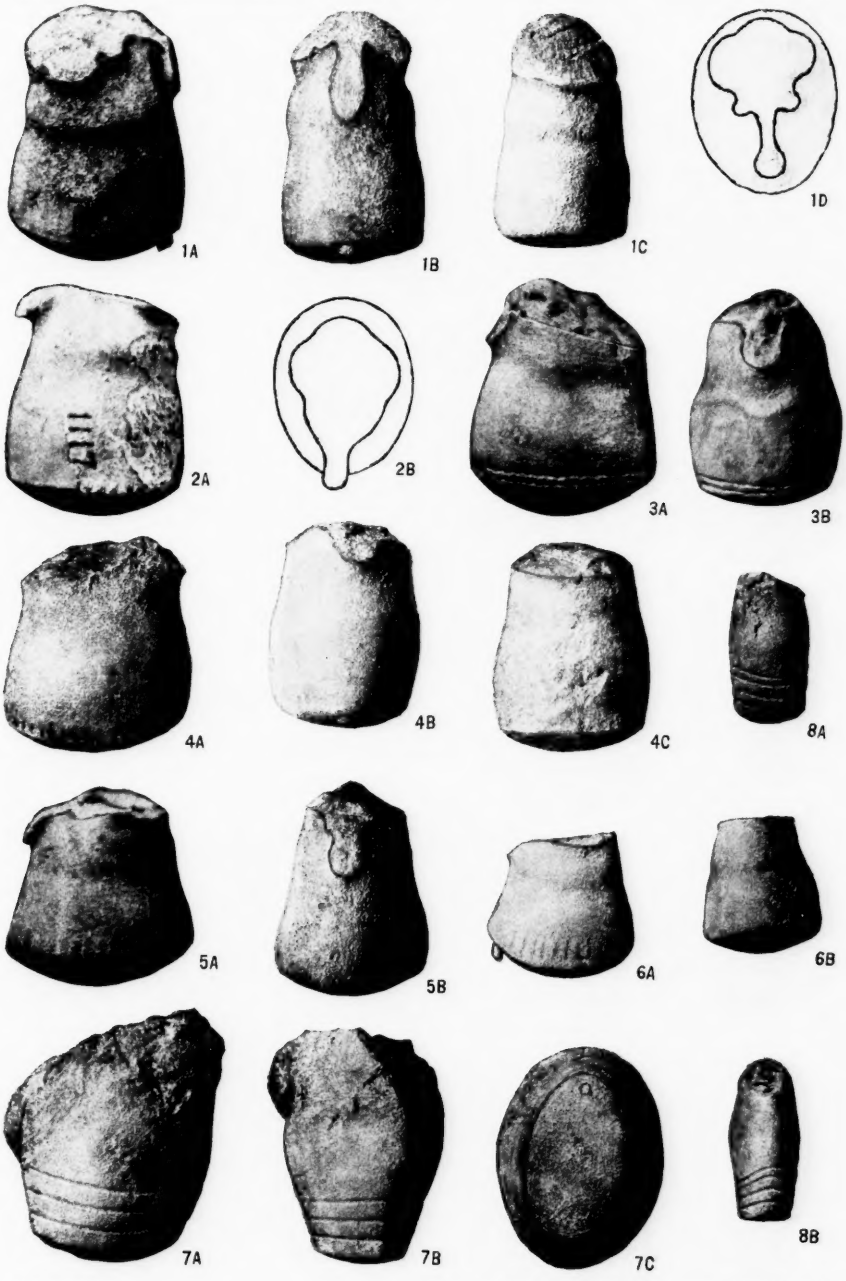
Fig. 4. *Stenogomphoceras inflatum* Foerste. A, lateral view, with ventral outline on right; B, ventral view; C, dorsal view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81452, in the U. S. National Museum.

Fig. 5. *Stenogomphoceras contractum* Foerste. A, lateral view, with central outline on left; B, ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81453, in the U. S. National Museum; holotype.

Fig. 6. *Stenogomphoceras pusillum* Foerste. A, lateral view, with ventral outline on left; B, dorsal view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. S-241, in the Savage collection; holotype.

Fig. 7. *Stenogomphoceras cf. inflatum* Foerste. A, lateral view, with ventral outline on right; B, oblique ventral view; C, viewed from beneath, showing the siphuncle. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81452-a, in the U. S. National Museum.

Fig. 8. *Stenogomphoceras gracile* Foerste. A, lateral view, with ventral outline on right; B, oblique ventral view. Port Byron, Illinois; in the Port Byron dolomite. Specimen no. 81454, in the U. S. National Museum.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7B
7C
8B

PLATE XXV

Figs. 1, 2, 3. *Lechritrochoceras lentidilatatum* Foerste. 1, lateral view, on apical side of spire; 2, similar view of another specimen; 3, ventral side of a living chamber. Specimens 1 and 2 are from the Moodie quarry in the southeastern part of Wilmington, Ohio; 3 is from Cedarville, Ohio; all are from the Cedarville dolomite. Specimen 1 is in the Austin collection in the U. S. National Museum; 2 is in the Welch collection in Wilmington College; both are cotypes. Specimen 3 is in the collection of the writer.

Fig. 4. *Ascoceras croneisi* Foerste. A, lateral view; B, ventral view; C, lateral view enlarged almost 3 diameters. Wauwatosa, Wisconsin, in the Racine. Specimen no. 2320-b, Museum of Comparative Zoology, Harvard University; one of the cotypes.

Fig. 5. *Ophidioceras welleri* Foerste. Lateral view, with upper end of living chamber free of contact with the preceding volution. Thornton, Illinois; in the Racine. Specimen no. 22939, Walker Museum, University of Chicago; holotype.

Fig. 6. *Ophidioceras wilmingtonense* Foerste. Lateral view of cast of an impression of the exterior of the conch. Wauwatosa, Wisconsin; in the Racine. Specimen no. 22930, Walker Museum, University of Chicago.

Fig. 7. *Lechritrochoceras cinctutum* Foerste. Lateral view. Clifton, on the Tennessee river, in western Tennessee; in the Osgood member of the Niagaran. Specimen in the collection of the writer; holotype.

Fig. 8. *Cyclorizoceras brevicorne* (Hall). Lateral view, with ventral outline on left; dorsal outline restored. The specimen consists of the living chamber, with one camera still attached; also the impression of the exterior of most of the remainder of the phragmacone; its apical end is missing. Racine, Wisconsin; in the Racine. Specimen 2118, American Museum of Natural History; holotype.

Fig. 9. *Cyrtorizoceras pusillum* (Hall). Lateral view, with ventral outline on right. The specimen consists of a cast of the interior of the living chamber, and the impression of the exterior of most of the phragmacone. Racine, Wisconsin; in the Racine. Specimen in same rock fragment as type of *Cyclorizoceras brevicorne* and Hall's figured specimen of *Lechritrochoceras desplainense*, numbered 2118 and 2126 respectively, in the American Museum of Natural History. Holotype.

Figs. 10, 11, 12, 13. *Inversoceras dayi* Foerste. 10, lateral view, with ventral outline on right; 11, living chamber, lateral view with ventral outline on left; 12, dorsal view of living chamber with dorsal neck or collar faintly trilobate in rear; 13, living chamber viewed from above, showing aperture. Schoonmaker quarry, Wauwatosa, Wisconsin; in the Racine. Specimens numbered 2164-a, 2158-b, 2158-a, and 2164-c, in the order here figured; Museum of Comparative Zoology, Harvard University; cotypes, the one mentioned first being most diagnostic.

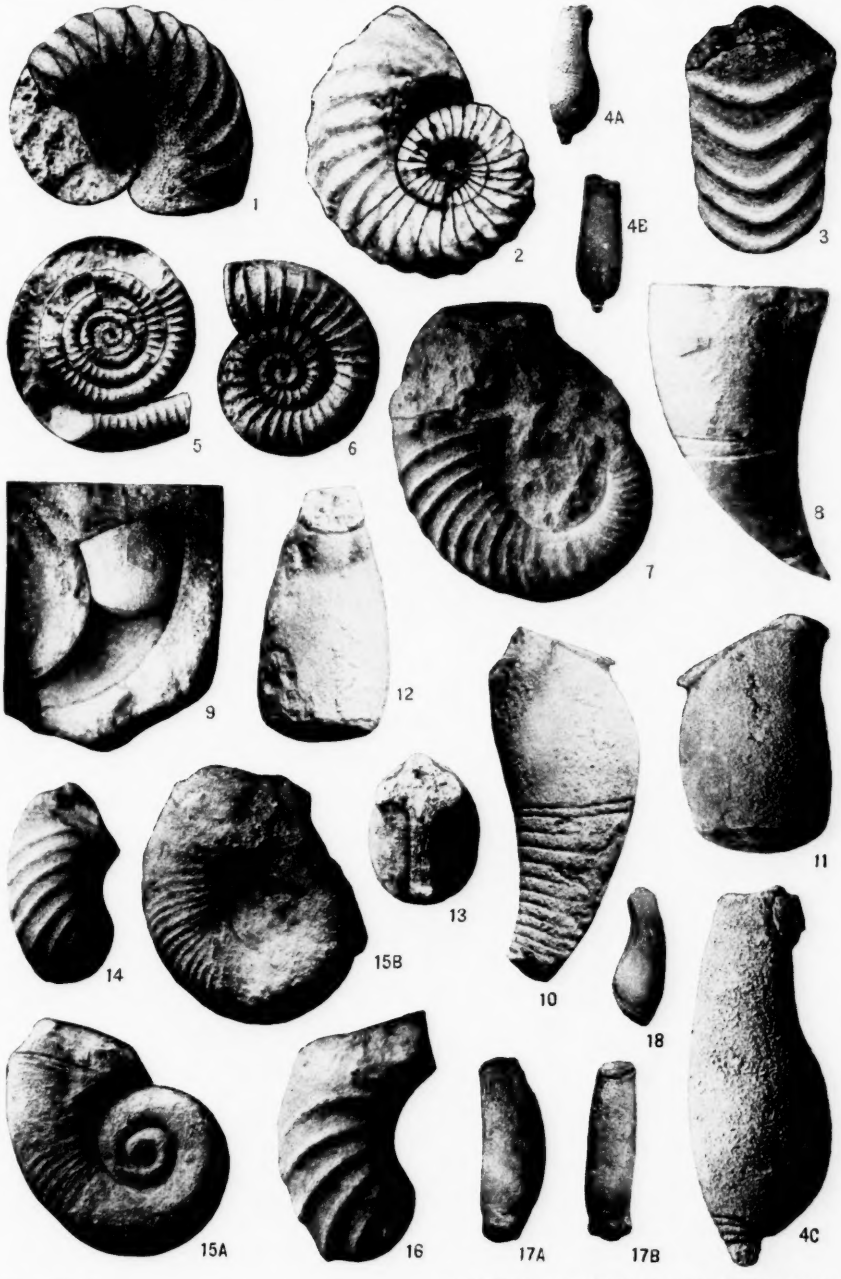
Fig. 14. *Lechritrochoceras notum* (Hall). Lateral view of living chamber, with ventral outline on left. Bridgeport, in the southern part of Chicago; Illinois. Specimen no. 2127-2, American Museum of Natural History; holotype.

Fig. 15. *Lechritrochoceras waldronense* (Hall). A, lateral view, showing apical side of spire; similar view of living chamber of another specimen. Waldron, Indiana; in the Waldron shale member of the Niagaran. Specimen no. 1956-A, B, American Museum of Natural History; cotypes.

Fig. 16. *Lechritrochoceras telleri* Foerste. Lateral view of living chamber, with ventral outline on left. Racine, Wisconsin; in the Racine. Specimen, no. 2127-1, American Museum of Natural History.

Fig. 17. *Ascoceras croneisi* Foerste. A, lateral view of gerontic enlargement of conch, with ventral outline on right; B, ventral view. Wauwatosa, Wisconsin; in the Racine. Specimen no. 2320-a, Museum of Comparative Zoology, Harvard University; chief cotype.

Fig. 18. *Ascoceras croneisi* Foerste. Lateral view of fragment, with ventral outline on right. Beneath that part of the specimen which includes the lower part of the last living chamber there are two very short camerae, beneath which is a longer one, the dorsal saddles belonging to the sutures of the septa of these camerae not being preserved. Wauwatosa, Wisconsin; in the Racine. Specimen no. 2322, Museum of Comparative Zoology, Harvard University.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THE IRON AND STEEL INDUSTRY OF YOUNGSTOWN, OHIO

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Much has been written during the past few years regarding the battle being waged by Youngstown to hold its eminent place in the nation's iron and steel industry and to retain a reasonable margin of profit. Since this is the oldest district in Ohio and until recently ranked second only to Pittsburgh (even now it stands third), one naturally wonders why so much concern should be given to its future status. Is it likely that it will decline in importance as other districts, possibly with better advantages, force keener competition? Sound, logical, scientific reasons are to be found in support of both the affirmative and the negative replies. However, it would appear that in the long run its fate will depend upon whether or not its advantages outweigh its disadvantages or vice versa.

YOUNGSTOWN—OHIO'S METALLURIGICAL PIONEER

The first furnace in Ohio was built in the Mahoning Valley in 1804. This plant utilized charcoal for fuel (developing the draft by means of water power) and nodular clay iron-stone associated with the coal beds. But the development of the iron business in the Mahoning Valley was consequent upon the discovery of a rich deposit of black-band ore below the coal at Mineral Ridge near Niles, and of coal making fairly good fuel in its raw state, found at Brier Hill in Youngstown.[1]

The Youngstown region first used Lake Superior hematite in 1856 and, despite transport difficulties, found it preferable to the local ore, because it had a much higher metallic content and made superior iron. It was not always used alone, but was frequently

[1] Butler, J. G., *Fifty Years of Iron and Steel*, Cleveland, 24 (1920).

mixed with local ore. Thus from "June 1879 to June 1880, the ores of the six principal works in the Mahoning Valley had the following sources:

	Long tons
Lake Superior and Canada	229,427
Pennsylvania and New York	28,219
Native Ohio ores	14,802"[2]

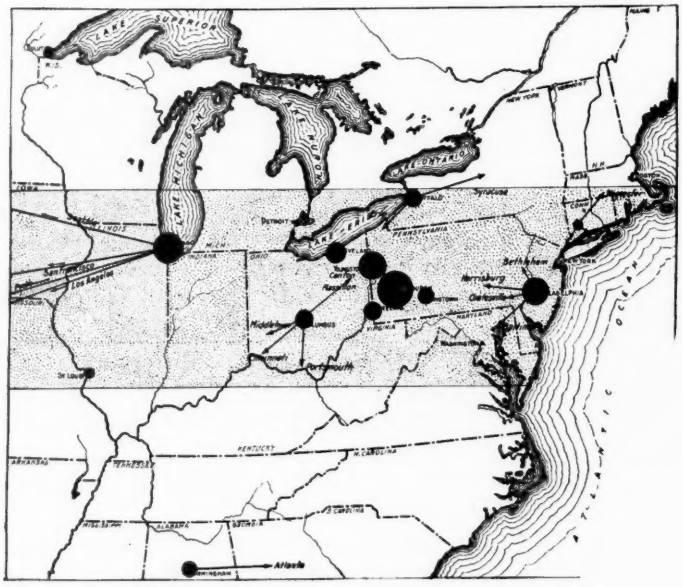

FIG. 1. DISTRIBUTION OF IRON AND STEEL DISTRICTS IN THE EASTERN HALF OF THE UNITED STATES AS GROUPED BY THE FEDERAL TRADE COMMISSION IN THE PITTSBURGH BASING CASE

The size of the circles is proportional to the ingot capacities of the districts. The arrows and accompanying names of cities indicate scattered plants belonging in this particular districting scheme. The area for Chicago is proportional to the ingot capacity of that district excluding plants in Colorado or on the Pacific Coast, which are indicated by arrows. For the time covered, the end of 1922, Detroit's capacity was too small to show proportionally. The shaded area represents the zone of densest steel consumption. Note Youngstown's favorable locus within it as well as its proximity to other important centers, which restricts its natural market area. (Data from *The Iron Age* and *The Iron Trade Review.*)

[2] Peattie, R., "The Geography of Ohio," *Geological Survey of Ohio, Bulletin 27* (Columbus), 103 (1923).

The district also began the use of Connellsville coke at an early date, though it, too, was frequently mixed with local fuel.

Thus from so humble a beginning and from the utilization of rather inferior local fuel and ore, Youngstown has become one of the world's greatest metallurgical centers (fig. 1). For 20 miles the Mahoning Valley is lined with mills; it is indeed a land of iron

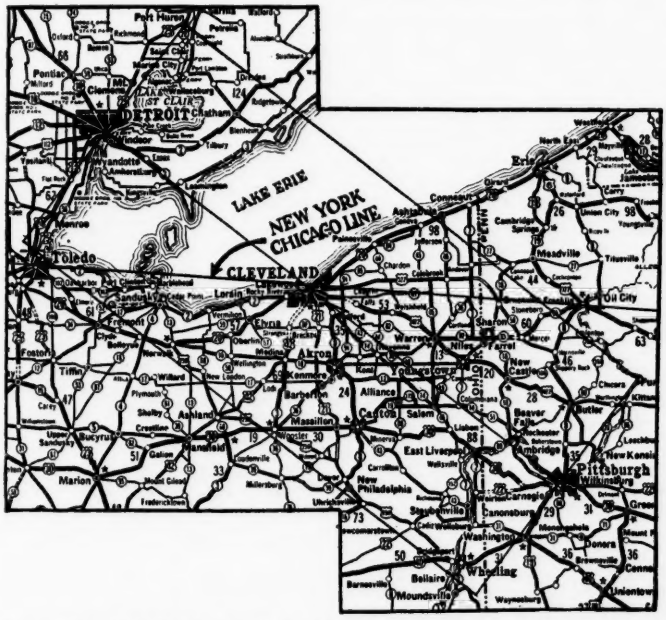

FIG. 2. The "Ruhr of America," throbbing with industrial activity, is the world's principal iron and steel region. And Youngstown, capital of the great *Valley Steel District*, occupies a highly strategic position within it. The entire region is covered with a network of railways and hard surface roads, which weld the rectangle into a cohesive whole. (Map by the Union Trust Company.)

and steel. And like Pittsburgh, Youngstown has become synonymous with steel.

ADVANTAGES FOR IRON AND STEEL MANUFACTURE

Youngstown's advantages for iron and steel manufacture are good, but less favorable than those of several rivals. Its out-

standing assets include a position (1) in the "Ruhr of America" (fig. 2)—one of the world's greatest iron and steel consuming regions; (2) on principal lowland routes from the coal fields of Pennsylvania and West Virginia to the lake ports of Ashtabula and Cleveland; (3) relatively near Lake Erie—59 miles by rail from Ashtabula and 67 from Cleveland—which enables it to reap the benefit of cheap water carriage on ore for at least 835 miles (to Cleveland); (4) relatively near important coal fields—Connells-

TABLE I[3]

Cost of assembling ore, coal, and limestone at Youngstown as of February 15, 1928

RAW MATERIAL	FROM	TO	COST
Iron ore	Mesabi Range mines	Duluth-Superior	$0.81 per gross ton
Iron ore	Duluth-Superior	Cleveland	0.70 per gross ton
Iron ore	Unloading, vessel hold	vessel-rail	0.13 per gross ton
Iron ore	Unloading, vessel rail	car	0.08 per gross ton
Iron ore	Cleveland	Youngstown	0.82 per gross ton
			$2.54 total
Coal	Connellsville	Youngstown	$1.42 per net ton
Coal	Kanawha Field	Youngstown	2.39 per net ton
Coal	Pittsburgh	Youngstown	1.34 per net ton
Coal	Pocahontas	Youngstown	2.64 per net ton
Limestone	Hillsdale and Walford, Pennsylvania	Youngstown	$0.55 per gross ton

ville, Kanawha, Pittsburgh, and Pocahontas; and (5) in an intensively developed area which is welded into a cohesive whole by an important railway net and by an excellent system of hard surface roads—by far the best in Ohio (fig. 2).

ASSEMBLY OF RAW MATERIALS

Since ore, fuel, and limestone comprise the greater part of the total furnace cost of making pig iron, from 78 to 90 per cent, their quality and accessibility constitute the critical factors of the in-

[3] These very valuable data were given to the writer by Mr. Andrew H. Brown, Assistant Transportation Commissioner of the Cleveland Chamber of Commerce. They represent informed estimates and are based upon extensive investigations.

dustry. Regarding the first, *quality*, that of all three is favorable, since Lake Superior ore, Connellsville, Pittsburgh, and Pocahontas coal, and Pennsylvania and Ohio limestone are used. The second point, *accessibility*, cannot be so easily disposed of, since the ore and fuel are separated one from the other by approximately 1,125 miles. Moreover, not a single raw material is unloaded at the stacks from lake carrier or river barge; this district is dependent solely upon the railway hopper, which causes it to have high assembly and production costs (tables I and II).

The approximate transportation costs chargeable to one gross ton of pig iron in Youngstown and in Cleveland and Pittsburgh, its two keenest rivals, are presented in table II. These figures tell far better than words, the inevitable handicap of Youngstown by reason of its off-water location.

TABLE II[3]

Total transportation costs chargeable to one gross ton of pig iron at Cleveland, Pittsburgh, and Youngstown

DISTRICT	COKE (2,050 LBS.)	ORE (4,000 LBS.)	FLUX (900 LBS.)	TO
Cleveland	$2.24†	$3.23	$0.20	$5.67
Pittsburgh	0.28 (100% waterborne)†	5.39*	0.35	6.02
Youngstown	1.78†	4.81*	0.22	6.81

† 70 per cent of the transportation costs chargeable to coke is included in the cost of assembling raw materials for pig iron and 30 per cent is borne by the by-products.

* In the cases of Pittsburgh and Youngstown, 80 per cent of the transportation cost of ore is calculable on the basis of direct shipments and 20 per cent on the basis of dock ore.

Iron ore.—Youngstown brings almost every pound of its iron ore from the Lake Superior Region, whence originates some 85 per cent of that used by the nation's titanic industry. While there are six different sources of this ore (fig. 3), about two-thirds of it originates in the Mesabi Range, which not only has the best ore,[4] but also the easiest and cheapest to mine. Here the ore,

[4] Mesabi ore shipped in 1925 averaged in percentage on analysis 52.05 iron, 0.061 phosphorus, 7.99 silicon, 0.68 manganese, and 11.14 moisture.

lying close to the surface, is covered by a relatively thin mantle of glacial till and is mined from open pits by steam shovels. Day and night (except during the winter) these huge monsters toil, biting into the soft red ore with their great jaws snatching as many as four and one-half tons at a single bite, and discharging it into 50 and 75 ton cars, which are loaded in five or less minutes.

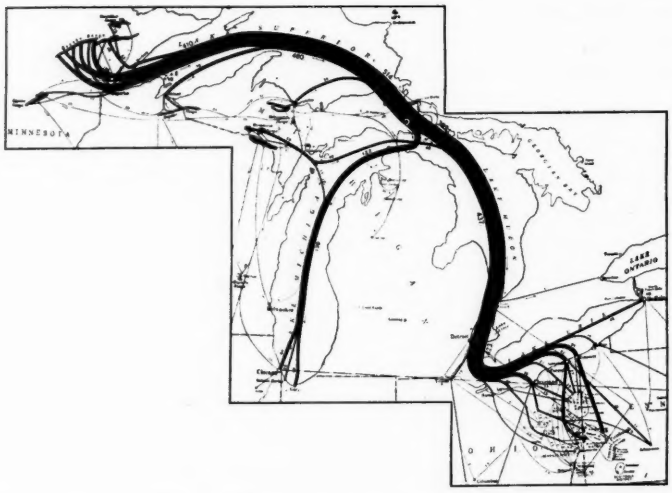

FIG. 3. The six ranges, comprising the Lake Superior Iron Region, send each year to the nation's hundreds of voracious blast furnaces from 50,000,000 to 60,000,000 tons of ore—more than four-fifths of our total production. Of this amount, about two-thirds pours into the "Ruhr" and nearly one-seventh into Youngstown. The recipient of so huge a tonnage could be little else than a land of iron and steel; Youngstown is called "a yawning pit where they make steel, surrounded by houses." The figures along the lines indicate the tonnage for 1926 in units of 100,000. (Map by The Lake Superior Iron Ore Association.)

These are then pulled out through the mine entrance to a railroad yard, where they are sampled and made into trains. The cars are then automatically weighed, and soon the train starts rolling down toward the Lake Superior ore docks—78 miles distant. Usually only two Duluth, Missabi and Northern trains and one Great Northern train are required to fill a boat, since each hopper carries from 50 to 75 tons.

As the train reaches the water, it moves onto a great concrete and steel dock, which juts out into the lake like a tremendous peninsula. These docks range in length from 900 to 2,304 feet. Once on the dock, the cars are switched to numbered pockets arranged for handling a group ore. The ore is stored here until the proper mixture is attained. These pockets hold from 300 to 400 tons in a 12-foot length of one-half the dock. One dock contains 384 pockets arranged in pairs and can store 154,000 tons of ore—enough to fill from 10 to 14 lake carriers. Atop these docks are four lines of track; when the ore is dumped, the empty cars are switched onto a return track and rushed back to the mines.

Then the long ungainly ore boat glides into its basin and is made fast to the dock. The hatches are opened, chutes are let down from the pockets above, and the ore comes crashing down,—filling a carrier with from 10,000 to 14,000 tons of ore in just a few hours. When loaded, the boat starts its journey down the lakes. It travels at an average speed of 12 to 13 miles per hour and makes the round trip of from 1,400 to 2,000 miles in about a week. Each vessel makes approximately 30 round trips during the season of navigation, which lasts a little more than seven months, thus traveling from 40,000 to 50,000 miles.

Upon arrival at Ashtabula, Cleveland, Fairport, or Conneaut (the ports which handle Youngstown's ore), the vessel ties up to a wharf on which are mounted great unloaders operating on tracks (fig. 4). These machines are almost uncanny in the performance of their task and are most fascinating to watch. They dig down into the hold of the vessel and soon appear with 15, 17 or 20 tons of ore. They are capable of unloading 10,000 tons in three or four hours. During the unloading the ore is tested.

Part of it (direct ore) is placed in waiting railway cars under the machines (fig. 4) and rushed to Youngstown, where it is placed in huge stock piles (fig. 5); the rest (dock ore) is retained at the rear of the unloaders in large storage piles (fig. 4) and conveyed to Youngstown during the winter. The furnaces so arrange their schedules as to absorb a steady stream of direct ore, since by so doing, they save about 25 cents per ton over the equivalent dock ore rate. By such means the Youngstown District gets millions of tons of ore annually—7,400,000 in 1928.

Of the ports which supply Youngstown with ore, Ashtabula and Cleveland handle the bulk; Fairport and Conneaut send small amounts. Both Ashtabula and Cleveland have access to Youngstown over rather level routes, which greatly facilitates traffic on

FIG. 4. UNLOADING ORE AT CONNEAUT

These great machines seize from the vessel's hold 15 tons at a single bite and disgorge into storage piles at the rear for shipment inland during the winter, or into waiting railway cars under the machines for immediate shipment to the furnaces. Note the great amount of storage space and the ease of unloading such boats (shells). The ore carrier and the unloader have contributed notably to our modern iron and steel preeminence. Ore is carried 1,000 miles for approximately one-seventh what it would cost to transport it by rail. The claim is made that these boats will carry a ton of ore a mile and consume only one ounce of fuel. (Photo from the *Iron Trade Review*.)

a heavy commodity like iron ore. Moreover they are quite near, Ashtabula being only 59 miles and Cleveland 67 miles distant.

Coal.—Youngstown is advantageously located with respect to coal—less so than Pittsburgh, but more so than Cleveland or any

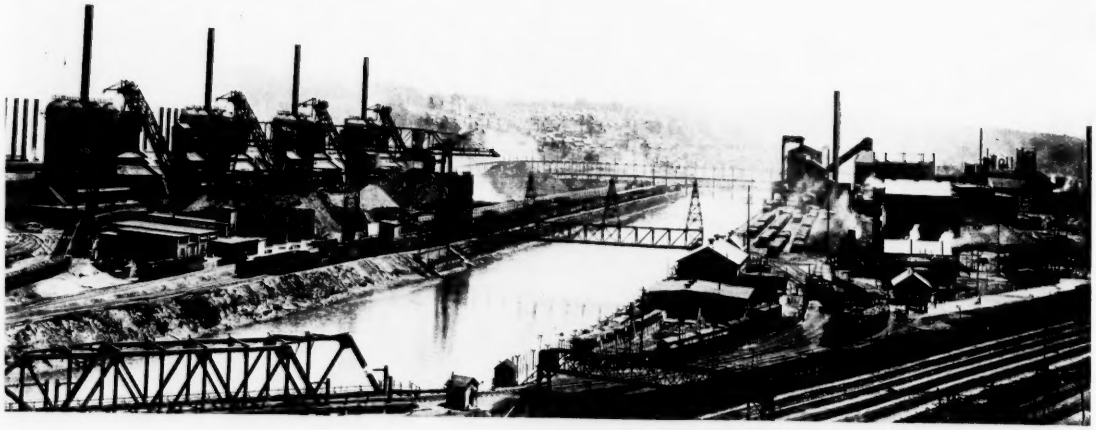

FIG. 5. PART OF THE WORKS OF THE YOUNGSTOWN SHEET AND TUBE COMPANY AT CAMPBELL: BLAST FURNACES ON THE LEFT AND BY-PRODUCT COKE PLANT ON THE RIGHT

Note how the industry hugs the river in order to get a copious supply of industrial water and to be near the railways, which necessarily follow it. The dwellings of the workers cling to the adjacent hills partly to overcome some of the smoke and dirt, but primarily because the *level land* must be given over to industry. On account of the dense smoke, it is only rarely that so good a photograph as this can be gotten. (Photo by W. A. Bartz of The Youngstown Sheet and Tube Company.)

other lake port (table I). Tremendous reserves of excellent fuel lie in Pennsylvania, West Virginia, eastern Kentucky, and even Ohio, though those of the latter are generally inferior for coking to those of the other three. Ohio coal is mostly steam coal.

Youngstown's voracious furnaces consume Connellsville and Pocahontas coals in the ratio of 85 and 15 per cent respectively, with 3,100 pounds of the mixture requisite to produce one net ton of coke. Greater utilization of Connellsville coal seems logical because of proximity and lower cost, and because many Youngstown companies acquired coal lands in that region during the reign of Connellsville bee-hive coke. Pocahontas held second place for a long time; and only after the introduction of the by-product oven did it really come into its own.

The several companies operating here—the Youngstown Sheet and Tube, the Republic Iron and Steel, and the Carnegie,—all own their own coal properties. It is said that the iron and steel interests of the country obtain more than three-fourths of their requirements from their own mines.[5]

Drift mining prevails in eastern Kentucky and West Virginia, since the seams outcrop on the hillsides. This method, which is both easy and economical, enables the coal to be loaded almost entirely by gravity into waiting gondola cars under the mine tipples in the bottoms of the valleys.

In western Pennsylvania, some drift mining is carried on along the river valleys, especially the Monongahela, where river barges, carrying 1,000 tons each (the equivalent of 20 freight cars) are loaded at the mine tipples. Here they are assembled into tows of about six barges and pushed down the river by stumpy little tugs. This goes on day and night, summer and winter. Obviously transportation costs are reduced to the minimum—three mills per ton mile on 5,000 ton lots over an average distance of 71 miles.[6] Elsewhere, as in the Youghiogheny field, south and southwest of Pittsburgh, and in the Connellsville and Latrobe fields north and east of it, shaft mining predominates. Here a

[5] Shurick, A. T., *The Coal Industry* (Boston) 260 (1924).

[6] "River Shipping and Industry," *American Rolling Mill Company*, Middletown, Ohio 23 (1923).

shaft is sunk straight down—perhaps 1,000 feet to a seam of coal, whence levels are run out in several directions.

The manufacture of coke.—The furnace fuel used by the Youngstown Sheet and Tube Company and by the Republic Iron and Steel Company is made locally in their own retort ovens (table III and fig. 5). The Carnegie Steel Company, on the other hand, makes no coke here, but relies upon its batteries of ovens located at Clairton in the Pittsburgh District. This is said to be the largest battery of coke ovens in the world. About 2,000,000 tons of coke are brought into Youngstown annually by rail.[7]

TABLE III

By-product plants in Youngstown, January 1, 1927[8]

COMPANY	NUMBER OF OVENS	ANNUAL CAPACITY (NET TONS)	
		Coal	Coke
Republic Iron and Steel	204	1,624,125	1,136,550
Youngstown Sheet and Tube	390	2,570,000	1,799,000

The advantages of the by-product over the bee-hive method are:

(1) It is practicable to transport coking coals to the retort ovens from any point within a favorable freight rate territory.
(2) An excellent grade of coke can be made from many coals ill-suited to bee-hive ovens.
(3) Retort ovens avoid all waste and even increase the percentage of coke; moreover, they supply valuable by-products and gas.
(4) By-product coke made near the blast furnaces costs considerably less than bee-hive coke made at the coal mines and transported to the furnaces, especially when the furnaces and the bee-hive district are separated by great distances.
(5) A substantial return on the investment in a by-product plant is obtained, despite the very large outlay.[9]

Limestone.—While the cost of limestone for making a ton of pig iron is small in comparison with that of ore or coke (tables I and

[7] "Youngstown, Ohio, The City of Industrial Opportunity," *Youngstown Chamber of Commerce*, 8.

[8] *The Iron Age*, January 20, 1927; 257.

[9] Camp, J. M., and Francis, G. B., *The Making, Shaping, and Treating of Steel*, Pittsburgh, 102 (1925).

II), it is nevertheless of sufficient importance to cause the companies to seek the deposits of greatest purity that are *accessible* and *near* the works. This is the case in the Youngstown District. An exception to this principle exists in the lake districts, which reach hundreds of miles into the northern part of the southern peninsula of Michigan for their supply. This is possible, however, only because both the quarries and the furnaces are on navigable water and can be reached by large lake carriers, which notably reduce transportation costs (table I).

Youngstown gets most of its limestone from northern Ohio near Gibsonburg and Marblehead and from western Pennsylvania. In the former region the conditions are very satisfactory for the production of high-grade fluxing material, since the stone lies close to the surface, varies from 60 to 110 feet in thickness, and contains 88 per cent calcium carbonate. The latter region is very near, contains limestone of excellent quality, which is 15 to 20 feet thick, lies in horizontal beds, and is covered by not more than 15 to 30 feet of surface material.

Scrap.—When scrap is used in making steel, economies are effected, time is saved, and a product is made which is the peer of that derived from the exclusive use of pig iron. The basis of the scrap industry is the fact that metal does not lose its identity: it continues to be a metal regardless of the number of times it is used.

The chief source, naturally, is the industry itself, it being estimated that about one-half that charged into the open-hearths originates in the mills themselves. But much is secured from the outside, since there is a supply wherever metal and metal products are used. The chief sources of "market scrap" are the larger steel consuming centers. Thus Youngstown, in the heart of the nation's "Ruhr," has ready access to a huge supply and gets annually by rail more than 1,500,000 tons.[10]

[10] "Youngstown, Ohio, The City of Industrial Opportunity," *Op. cit.*, 8.

YOUNGSTOWN IN RELATION TO MARKETS

Nearness and economical accessibility to important markets are fundamental to the successful development of any metallurgical district.

Major Market the "Ruhr of America."—The Valley District, with Youngstown as its pulsating heart, lies strategically in the "Ruhr of America"—a rectangle 100 x 180 miles, which throbs with industry (fig. 2) and is undoubtedly the greatest iron and steel region, both primary and secondary, in the world. Here dwells one-twentieth of the nation's inhabitants, and here are three of its ten largest cities and nine urban centers with populations exceeding 50,000—all indicative of its tremendous consumptive demands.[11]

But despite Youngstown's favorable position in the "Ruhr," competition is most intense, for within it are eight other metallurgical districts—Canton, Cleveland, Detroit, Pittsburgh, the Shenango Valley, Steubenville, Toledo, and Wheeling (fig. 3).[12] Nevertheless, Youngstown markets steel in every part of the "Ruhr": it is one of Cleveland's most formidable rivals in the Michigan automotive market, despite a freight rate advantage of the latter of $.60 per ton. And of the 161,944.5 tons of steel consumed in the city at the mouth of the Cuyahoga (itself a major iron and steel center) from July 1, 1920 to December 31, 1920, the Mahoning and Shenango Valleys District supplied 27,117. Of this amount Youngstown contributed the bulk, since the largest tonnage (12,484) was sheets, for which it is world-famous.[13]

The local market.—Because of its early start in iron and steel manufacture, Youngstown has many transforming industries which consume the semi-finished products of the primary branch. They make blast furnace equipment, boilers, bridges, concrete reinforcement, cranes, engines, forgings, lath, machine shop products, steel furniture, structural steel, steel sash, stoves, stove

[11] Martin, Earle, "The Crossroads of Commerce," *Trade Winds*, March, 1929, p. 3.

[12] This region, frequently dubbed the *Middle District*, has an estimated steel ingot capacity of 27,500,000 tons out of the country's total of 54,807,343.

[13] "Pittsburgh Plus," *Cleveland Chamber of Commerce*, 5 (1923).

pipe, etc. Many of these secondary industries chose Youngstown for their plants in order to be *near* cheap fuel, *near* the source of their raw material, and *near* the ultimate market. For instance, it would be difficult to find a more logical location than the one under consideration for the establishment of the works of the United Engineering and Foundry Company, one of the largest builders of rolling mill and other heavy machinery in the United States.

The distant domestic market.—The South, the Southwest, and the Middle West are great steel markets. The first two, however, are a sort of "no-man's land" in that no one district completely controls them, as is the case with the Eastern market, which is dominated by the Bethlehem Steel Corporation with its strategically located plants at Bethlehem, Buffalo, Johnstown, Sparrows Point and elsewhere. Districts competing for their business are Birmingham, Chicago, Pittsburgh, Sparrows Point, Steubenville, Youngstown, and Wheeling. Even several European countries invade this mart using steel as return cargo on vessels that transport cotton thither.[14] Of all the competitors mentioned, Youngstown is handicapped most, since it alone is unable to use water transportation. All the Ohio River districts can ship by barge over a *new Ohio* with a year-round stage of nine feet; Chicago and Gary may ship by rail either to Cairo or St. Louis and thence by barge; Birmingham ships by rail to Birmingport—26 miles distant—and then by barge to Mobile and New Orleans; Sparrows Point, located on salt water, floats its steel to Gulf ports.

Since the saving averages from $2.00 to $3.00 per ton above the rail rate from Pittsburgh to Memphis and the time required is no greater than by train, Youngstown is up against a genuine snag insofar as competition is concerned in these markets. With the fine equipment used by the Carnegie Steel Company, a saving in freight between Pittsburgh and New Orleans of probably 40 per cent of the rail rate is effected.[15] Within four years this great

[14] The freight rate on steel products from England and Belgium to Galveston is $3.55 per ton; from Birmingham to Galveston by rail, it is $12.77 per ton. Such a low rate naturally facilitates the importation of foreign steel into the South.

[15] Taylor, E. H., "Freighting on the Ohio," *The Country Gentleman*, Sept., 1929, p. 139.

company spent $5,000,000 building an industrial navy, consisting of 14 steamers and almost 400 barges; and the number grows continuously.[16]

Tows of steel in ever growing numbers are moving over the Ohio, Missouri, Mississippi, and Warrior Rivers. They fill the local needs of Parkersburg, Cincinnati, Louisville, Evansville, St. Louis, Kansas City, Memphis, Mobile, and New Orleans; they also carry steel to them for trans-shipment inland by rail, and in the case of Mobile and New Orleans for shipment to the Pacific Coast and to foreign countries. Several of the large Pittsburgh concerns have huge warehouses and storage yards, where they accumulate thousands of tons of all kinds of steel for immediate shipment to large cities or to the oil fields of the South and Southwest. Faced by this dilemma, Youngstown attempted to make direct rail connections with the Ohio River at Smith's Ferry, Pennsylvania, in order to benefit partly by barge rates on coal inbound and on steel outbound (pp. 138–142). Generally speaking, steel manufacturers can save in transportation costs by shipping part way by water and then transferring to rail, providing, of course, that the haul by barge is sufficiently long so that the saving in transportation cost is not offset by transfer charges at river terminals.

OFF-RIVER LOCATION HANDICAPS

From a strictly geographical point of view, the iron and steel industry is concerned with transportation almost *in toto*, since it is basal at every single stage from the assembly of the raw materials to the distribution of the manufactured articles. As transportation is the keystone of economic activity, every metallurgical center should excel in it. Comparing the nation's five leading districts—Pittsburgh, Chicago-Gary, Cleveland, Philadelphia,[17] and Youngstown (fig. 1), the latter appears to have the least satisfactory transportation facilities, for it lacks the economies

[16] *The Iron Age*, June 14, 1928, p. 1684.

[17] The Philadelphia District includes Bethlehem, Coatesville, Harrisburg, and Sparrows Point, a grouping used by the Federal Trade Commission in the Pittsburgh basing case.

afforded by location on navigable water—ocean, lake, river, or canal. Since Youngstown's most formidable rivals are Pittsburgh and Cleveland, let us compare them in transportation assets. Pittsburgh, capital of the world of iron and steel, is the nodal point where three rivers join—the Allegheny, Monongahela, and

FIG. 6. If the "Ruhr's" dream of a canal connecting Lake Erie with the Ohio River is ever realized, the entire region will stand upon the threshold of a new industrial era. It is to be hoped that this dream will come true, for *economical water transportation* on *heavy* and *bulky* and *cheap* products is sorely needed by Valley manufacturers to enable them to compete with rivals, whose plants adjoin navigable lakes, rivers, canals, or oceans. (Map by the Youngstown Chamber of Commerce.)

Ohio. Thus it enjoys low rates via river barge on fuel inbound[18,19] and on some steel outbound. Cleveland reaps the rewards of lake

[18] It is said that the annual savings on the 24,469,315 tons (essentially coal) carried on the Monongahela in 1926 amounted to about $16,000,000.[19]

[19] "Our Runaway Rivers," *The Jones and Laughlin Steel Corporation*, (Pittsburgh) p. 3 (1927).

and river location by getting cheap transportation rates on ore and limestone inbound and on part of its products outbound. Youngstown, on the other hand, is completely land-locked and hedged in by restrictive rail freight rates.

What Proposed Lake Erie and Ohio River Canal Would Mean to Youngstown.—This district, like Pittsburgh and all other industrial centers in the "Ruhr," has long sponsored the Lake Erie and Ohio River Canal (fig. 6). This route would involve improving the Beaver and Mahoning Rivers as far as Youngstown and digging a canal from there through the divide to Ashtabula Harbor on Lake Erie. The canal would have a depth of 12 feet and could support an annual traffic estimated at about 38,000,000

TABLE IV[29]

Annual inbound traffic of railroads serving Youngstown

COMMODITIES	TONS
Coal	11,000,000
Ore	8,500,000
Limestone (for furnaces)	2,000,000
Coke other than by-product manufactured at the steel plants	2,000,000
Scrap iron and steel	1,500,000
Miscellaneous traffic to industries and other consignees	3,500,000

tons. No material physical difficulties are evident and the route has been recommended by Government engineers.

If this project should become a reality, Youngstown and Pittsburgh could get ore and limestone delivered from Lake Erie ports at an estimated cost of less than 0.7 ¢ per ton mile, and Youngstown could get coal at a probable cost on the return movement of 0.4¢ per ton mile. It would also enable this district to ship steel products to the Ohio River and thence to the Middle West, South, and Southwest. This canal, however, is a mere possibility.

Transportation by Rail.—In a high rolling country full of deep sharp valleys which can be crossed only at great expense both of construction and of operation, the railroads naturally follow stream courses (fig. 5). The chief routes connecting the coal fields of

[29] "Youngstown, Ohio, The City of Industrial Opportunity," *Op. cit.*, p. 8.

Pennsylvania and part of West Virginia with Ashtabula and Cleveland on Lake Erie follow fairly level routes via Youngstown.

While the city is by no means the great transportation center that many of its steel rivals are, *e.g.*, Chicago, Buffalo, Pittsburgh and Cleveland, it nevertheless requires the services of more than 1,000,000 freight cars to carry its annual commerce. Table IV indicates the vast railway tonnage inbound (estimated).

Four great trunk line railroads—the Baltimore and Ohio; Erie; New York Central, and Pennsylvania—together with the Pittsburgh and Lake Erie, the Lake Erie and Eastern, and the Youngstown and Austintown, serve the district.

During the past several years Valley interests strove diligently, though unsuccessfully, to persuade the Interstate Commerce Commission to allow the Pittsburgh, Lisbon and Western Railway to build two stretches of track of 27 and 13 miles so as to connect the Youngstown District[21] with the Ohio River at Smith's Ferry, Pennsylvania. While the Commission found that public convenience and necessity require provision of rail transportation between the Valley and the Ohio River in connection with transportation on the latter and connecting waterways, it felt that such service could be satisfactorily furnished by existing carriers. Accordingly, the Pennsylvania and the Pittsburgh and Lake Erie agreed to provide facilities for transferring coal from barges to railway cars and steel from cars to barges at Conway and Colona, Pennsylvania—43.8 and 41 miles from Youngstown respectively.

By the Smith's Ferry route, Youngstown interests had figured on getting their fuel delivered from the Connellsville District at a total through rate of approximately $.90 per ton as against the through all-rail rate of $1.42 from the Connellsville, and $1.34 from the Pittsburgh Districts (table I). They contend that the rate for the rail haul should be approximately $.75, though the Pennsylvania and the Pittsburgh and Lake Erie have both proposed $1.02. But even with the latter figure, Valley steel interests should make huge savings in their transportation costs.

[21] The Youngstown or Valley District includes a ganglion of towns—Farrell, Girard, Hubbard, Leetonia, Lowellville, New Castle, Sharon, Sharpsville, Struthers, Warren, West Middlesex, and Youngstown.

MINOR LOCATION FACTORS

Among the location factors of minor importance in the iron and steel industry are (1) labor, (2) industrial water supply, and (3) level land.

Labor.—In both the cost and composition of labor Youngstown and Pittsburgh are identical, because their geographical and industrial conditions are similar. It is estimated that about 42 per cent of the metallurgical workers are foreigners, (34 nationalities are employed by one company), 8 per cent are negroes, and 50 per cent are native whites.

The cost of labor is a relatively small item in the total cost of making iron and steel, since machines replace human hands wherever possible. Mary Heaton Vorse has presented this forcefully and vividly:

> "Three things impress you when you go into the mills: the size, the absence of men, the absence of haste. Here a tremendous work is in progress. Here is being manufactured the steel skeleton of our monstrous civilization. Here before your eyes you may see it being made from fire and iron with the help of great machines. That is what you think at first.
>
> "Later you say 'Oh, men are helping, too!' This is an after-thought."[22]

Industrial water.—One reason why iron and steel plants line the river for 20 miles (figs. 5 and 7) is to have ready access to a large supply of industrial water. It is estimated that the flow of the Mahoning is used more than seven times as the stream passes through the valley. Ninety-seven per cent of the water used by the Youngstown Sheet and Tube Company originates in the river, the remainder emanating from several artificial lakes about 10 miles away. The Carnegie and Republic companies utilize river water entirely, though the latter has a small supplementary reservoir.

Water from rivers is less satisfactory for industrial use than that from lakes (unless the stream originates in a lake as does the Niagara River) for the water is generally polluted and warm, the latter a result of almost continuous utilization for cooling.

[22] Vorse, Mary Heaton, *Men and Steel* (New York) 19 (1920).

All the water here is hard and must therefore be filtered and softened for boiler use; that employed for cooling is filtered only.

Level land.—Youngstown, like Pittsburgh, is a victim of topography: it lies in a dissected plateau,[23] where there is a dearth of level land for expansion and development (fig. 5)—a serious mat-

FIG. 7. This view of part of the works of the Republic Iron and Steel Company shows that the Mahoning is a river of steel works. Note the ceaseless activity. "All day the yard engines puff back and forth; all day the rows of chimneys belch flame. By night Youngstown's sky line is incandescent with the magnificence of the never-ending blasts; by night it looks as though the end of the world were at hand." (Photo from the Youngstown Chamber of Commerce.)

ter for an industry performing so many different tasks in contiguous or near-by plants and in single-story buildings. Of all industries, the iron and steel branch needs the most land, and it should

[23] The part of the plateau in which Youngstown lies is *glaciated*; hence the valleys are less deep than at Pittsburgh, due to glacial erosion of the hills and to glacial deposition in the valleys.

also be cheap. If the only available flat land is confined to narrow ribbons of flood plain, there is naturally not much of it and what there is cannot be cheap. The distribution of the mills along the Mahoning River is due in large measure to the availability of level land there.

THE PROBABLE FUTURE

In the preceding pages the following salient facts regarding the iron and steel industry of Youngstown were noted: (1) the district ranks third in capacity among those of the United States (fig. 1); (2) it was only recently ousted from second place by Chicago-Gary; (3) it lies strategically in the "Ruhr of America," one of the most densely populated and one of the largest steel consuming districts in the world; and (4) it produces a surplus, which must be sold outside its natural market area, and in this trade encounters severe competition by reason of its off-water location. All competitive districts have direct access to lakes, rivers, canals, or oceans.

Keeping these points in mind, does it appear that the future augurs well or ill for this great district? *Is the Valley industry actually being choked by high freight rates.* President James Campbell of the Youngstown Sheet and Tube Company recently stated that if the district failed to secure direct rail connection with the Ohio River, the investment of hundreds of millions of dollars in Mahoning Valley plants would be endangered and the industry would die out as the mills deteriorate and are scrapped.[24] In truth a capacity of 1,700,000 tons has been dismantled in the *Middle District,*[12] of which Youngstown is an important part, and an equivalent amount has not been replaced.[25] This may be significant!

On the other hand, the inertia of invested capital helps to maintain production in a well established center such as this. More-

[24] *The Cincinnati Times-Star,* August 8, 1928, p. 10.

[25] *Docket No. 17,000, Rate Structure Investigation, Part 6, Iron and Steel Articles and Consolidated Cases. Domestic Rate Situation; United States Steel Corporation,* p. 25 (1927).

over, "Where production has been large and continuous, it may be assumed that the favorable conditions on the whole outweigh the unfavorable ones."[26] This would seem to be borne out by the percentage earnings of capitalization by the companies operating here (table V), yet they are lower than they might be on account of conservative financial policies followed by most steel companies.[27] Furthermore, the steel industry is largely a fixed thing: "Plants cannot be moved, and the relative production of different districts can change only gradually, chiefly by growth at one point and decadence at another, a slow process at most."[28]

Perhaps Youngstown may not grow and prosper as will (1) Chicago, Gary, Cleveland, and Buffalo on the lakes; (2) Sparrows

TABLE V

Earnings on capitalization of companies operating in Youngstown

COMPANY	1925	1926
Republic Iron and Steel	4.63	5.30
United States Steel Corporation of which The Carnegie Steel Company is a part	5.48	6.64
Youngstown Sheet and Tube	9.41	10.09

Point on tidewater; or (3) Birmingham and Pittsburgh on their rivers. Waterside locations have proved highly advantageous to them; Youngstown alone is land-locked. But its early start, tremendous financial investment, propinquity to great markets, nearness to coking fuel and limestone, proximity to Lake Erie ports to which ore is carried economically, and rail-river transportation (soon to be realized), favor iron and steel manufacture. Moreover, all three companies are units in great organizations which have mills distributed far and wide throughout the country, and this should enable their executives to keep the Youngstown plants at a point of maximum efficiency.

[26] Leith, C. K., "The World Iron and Steel Situation in Its Bearing on the French Occupation of the Ruhr," *Foreign Affairs*, June 15, 1923, p. 137.

[27] Docket 17,000, *Interstate Commerce Commission, Rate Structure Investigation, Part 6, Iron and Steel Articles*, sheet 11 (1927).

[28] *The Iron Age*, June 14, 1928, p. 1704.

NEW SPECIES OF BRYOZOANS FROM THE PENNSYLVANIAN OF TEXAS

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The Pennsylvanian marine deposits of the Mid-Continent region are commonly fossiliferous, and in many places the fossils are not only beautifully preserved but are exceptionally abundant. The majority of species, however, as identified by most workers, are long-ranging and therefore of little value as markers of definite geological horizons. Locally the assemblage of organisms in given beds is very uniform and may be used with other criteria in recognizing parts of the stratigraphic column. Such assemblages have not as yet been proved reliable for correlation of formations that are geographically distant.

Partly in connection with paleontologic researches of the geological surveys of Texas, Oklahoma, Kansas and Nebraska, and partly as an item in a general program of cooperative study of the Pennsylvanian strata in the central United States fostered by the American Association of Petroleum Geologists, the writer has collected and is studying the fossils from many localities and horizons of this age.

The bryozoans comprise a section of the faunas to which scant attention is given by most stratigraphers and paleontologists, apparently more because of difficulty in identifying them positively than because of lack of value for correlation. The variety of species is great, but with care in observation it is really not hard to distinguish characters that are constant in each group of specimens and which accordingly are a reliable basis for specific differentiation. At the invitation of Dr. G. E. Condra, of the University of Nebraska, who for many years has been specially interested in fossil bryozoans, the writer is preparing to collaborate in a monographic study of the Pennsylvanian bryozoans. Work

on the species here described had been completed prior to entering into these more comprehensive plans and since the fenestellid group will be attacked in particular by Dr. Condra, it seems best to add to descriptions of Texas bryozoans already published by the writer,[1] these new species.

The species come from two localities in north central Texas, both rich in bryozoans. One is the famous collecting ground for upper Pennsylvanian ammonoids about one mile west of Graham, Texas. The strata from which the bryozoans were collected belong in the upper part of the South Bend shale member of the Graham formation, which is the basal division of the Cisco group. The other locality is about twelve miles northwest of Bridgeport, in Wise County. The bryozoans occur in shaly seams between the beds of a prominent limestone that is identified as Ranger, one of the formations of the upper Canyon group.

Acknowledgment is made of indebtedness to Mr. Frederick B. Plummer, of the University of Texas, for aid in field work and cordial cooperation of many years standing in stratigraphic and paleontologic study of the Texas Pennsylvanian.

DESCRIPTION OF SPECIES

Fenestella bispinulata Moore n. sp.

Plate XXVI, figs. 9, 10

The most abundant bryozoan in the collection northwest of Bridgeport is a fenestellid which is readily distinguished by an alternating double row of small spines along the keel. We have several hundred free specimens, some of which are nearly 2 cm. in length and width. The surface of the zoarium is commonly not plane, but is unevenly warped upward and downward. The branches are straight with more or less frequent bifurcations, in some specimens occurring rather uniformly at intervals of 2 to 3 mm. The branches are in general about 0.27 mm. wide and 0.4 to 0.5 mm. thick, the thickness being commonly nearly twice the

[1] Moore, Raymond C., A bryozoan faunule from the Upper Graham formation, Pennsylvanian, of north central Texas. Jour. Paleontology, 3, 1-27, 121-156, (1929).

width. Measurement of many specimens shows a maximum range of 9.6 to 11.5 branches in 5 mm., the average being 10.3. The fenestrules are subquadrate to elliptical, the sides being more or less distinctly indented by projecting zooecial apertures. The average width is 0.22 mm. and the length 0.4 mm. The maximum range in the number of fenestrules in 5 mm. is 9 to 10, the average being 9.5. The dissepiments are about 1.14 mm. in width, slightly expanded at point of union with the branches, a little depressed on the obverse side but even with the reverse side of the branches. The zooecial apertures are subcircular, about 0.08 mm. in diameter, surrounded by a thin but distinct peristome; there are 17.5 to 20 zooecia in 5 mm., the typical number being 18.5 to 19. A rounded carina of moderate width occurs on the obverse side of the branches, and carries a double row of small spines alternating in position and so arranged that one spine occurs obliquely below each zooecial aperture; the spacing of each row of spines, therefore, corresponds to the adjacent range of zooecial apertures.

Aside from measurements of branches, fenestrules and zooecia, which together distinguish *F. bispinulata* from other described Pennsylvanian species, the most noteworthy character is the binodate character of the keel, which calls to mind *F. binodata* Condra and *F. geminanoda* Moore. Condra's species is much more robust having only 6 to 8 branches in 5 mm. and 6 to 6.5 fenestrules in this space. In *F. geminanoda* from the South Bend shale west of Graham there are 12 branches and 7.5 to 8.5 fenestrules in 5 mm., the zooecial apertures numbering constantly about 17.5 in this space In this species also the peristome appears to be incomplete on the posterior side.

Horizon and locality.—Ranger limestone, twelve miles northwest of Bridgeport, Texas.

Fenestella minuta Moore n. sp.

Plate XXVI, figs. 7, 8

Branches straight, 0.17 to 0.22 mm. in width and about the same in thickness, 13 to 15 in 5 mm. Fenestrules subelliptical, more or less indented at the sides by projecting zooecia, 0.11 to

0.2 mm. (typically 0.14 mm.) in width, and 0.34 to 0.42 mm. in length; there are 9.5 to 10.5 fenestrules in 5 mm. Dissepiments about 0.12 mm. wide, expanding slightly at union with branches. Zooecial apertures subcircular, about 0.08 mm. in diameter, surrounded by a thin but distinct peristome, 25 to 27 in each row in 5 mm. A narrow, very slightly elevated median keel carries a single series of small spines or nodes, the average interval between them being 0.27 mm.; but they range from 23 to 30 in 5 mm. Reverse of zoarium smooth or faintly striated longitudinally.

This species appears readily distinguishable from other known Pennsylvanian fenestellids in the close spacing of the branches and zooecial apertures, combined with moderately elongate fenestrules. It perhaps most closely suggests *F. mimica* Ulrich, which differs in slightly wider spacing of branches and zooecia, closer spacing of fenestrules and a less conspicuous development of nodes on the keel. *F. minuta* is a rare species, being represented in our collection by half a dozen specimens.

Horizon and locality.—Ranger limestone, twelve miles northwest of Bridgeport, Texas.

Fenestella geminanoda Moore n. sp.

Plate XXVI, figs. 5, 6

Branches straight, about 0.27 mm. wide and 0.35 mm. thick, with 12 branches in 5 mm. The dissepiments, about half the width of the branches, are slightly depressed on the obverse face but not depressed on the reverse side. Fenestrules subelliptical, margins distinctly indented by projecting zooecia, 7.5 to 8.5 fenestrules in 5 mm. Zooecial apertures subcircular, about 0.1 mm. in diameter, surrounded by a thin peristome which in many cases is incomplete on the posterior side; there are 17.5 zooecia in 5 mm. and two to three to each fenestrule. The median portion of the obverse face of the branches shows a clearly defined carina on which is a double row of low alternating nodes, about 18 in each series in 5 mm.; there is one node obliquely below each zooecial aperture. The obverse side of branches and dissepiments

bear more or less distinct longitudinal granules; the reverse side is somewhat unevenly striated and slightly nodose.

In the well defined biserial arrangement of nodes along the keel, our species suggests comparison with *F. binodata* Condra and possibly *F. conradi-compactilis* Condra. However, the number of branches in a given space is considerably greater in *F. geminanoda* than in either of Condra's species, and the number of fenestrules differs somewhat. The keel of *F. geminanoda* is less prominent and the apertures are relatively more elevated and projecting into the margins of the fenestrules. The binodate character of the keel in this Texas species is apparently much more strongly developed than in *F. conradi-compactilis.*

Horizon and locality.—Near top of South Bend shale member of the Graham formation, one mile west of Graham, Texas.

Fenestella nodulosa Moore n. sp.

Plate XXVI, figs. 3, 4

About two dozen specimens in our collection show constant and distinctive characters which readily differentiate them from associated species and other described forms. Branches straight, subrhombic in cross section thicker than wide, the thickness uniformly 0.37 mm. and the width about 0.28 mm.; ten branches occur in 5 mm. Dissepiments about 0.28 mm. thick and 0.17 mm. wide, depressed on the obverse side but practically even with the reverse side of the branches. Along the side of branches and dissepiments midway between obverse and reverse faces is a narrow, very sharp but low ridge. The obverse side of the branches is smooth, that of the dissepiments faintly ridged or striated; the reverse face of branches and dissepiments carries moderately strong, fairly numerous nodes or pustules irregularly arranged, some rounded and some sharp pointed. The fenestrules are subelliptical about 0.26 mm. wide by 0.4 to 0.5 mm. in length, 7.5 to 8.5 occurring in 5 mm. Zooecial apertures subcircular about 0.1 mm. in diameter, strongly elevated from the surface of the branches and surrounded by a thin peristome directed somewhat obliquely; our specimens show a range of

23.5 to 24 apertures in 5 mm. The median portion of the branches between the zooecia carries a low narrow knife-like carina which carries regularly spaced, laterally appressed prominent spines, the base along the keel measuring 0.2 to 0.28 mm. and the height up to 0.2 mm.; the axis of the spines is approximately at right angles to that of the branches. There are 11.5 to 12.5 spines in 5 mm., the average interval being 0.42 mm.

In measurements of branches and fenestrules our species corresponds to described examples of *F. spinulosa* Condra, *F. sevillensis* Ulrich, *F. parvipora* Rogers, and *F. conradi* Ulrich. The first two of these have much more widely spaced zooecia and distinguishing surface characters. In *F. parvipora* the zooecia and nodes are more closely spaced and the reverse is striated. In *F. conradi* the character of the nodes, keel, reverse side of the branches, the shape of the fenestrules and the slightly wider spaced zooecia are all unlike our specimen. In general appearance, especially the nodose character of the reverse side, *F. nodulosa* calls especially to mind our species *F. spinulifera* and *F. spinulifera pustulosa* from the Wayland shale of Texas. However, in these forms the branches are distinctly more widely spaced, the fenestrules larger, the spines more closely crowded along the keel, the branches are less thick and lack the lateral knife-like margins.

Horizon and locality.—Near top of South Bend shale member of the Graham formation, one mile west of Graham, Texas.

Fenestella nodulosa var. *minor* Moore n. var.

Plate XXVI, figs. 1, 2

Four very well preserved specimens in our collection differ from typical *F. nodulosa* in having more delicate branches and dissepiments, the branches measuring about 0.24 mm. in width by 0.28 mm. in thickness; there are 10 to 11.5 branches in 5 mm., and 8 to 9 fenestrules in 5 mm. The number of zooecia in 5 mm. is constantly 21 and the number of spines along the keel 15 in 5 mm. The obverse face is faintly striated and the sharp lateral margins are not developed. The reverse face is strongly nodulose. The

uniformity of the differences in measurements indicates that this form is distinct from *F. nodulosa*.

Horizon and locality.—Near top of South Bend shale member of the Graham formation, one mile west of Graham, Texas.

Fenestella condrai Moore n. sp.

Plate XXVI, figs. 12, 13

The most abundant bryozoan in the South Bend shale west of Graham, represented in our collection by several dozen beautiful specimens, is the delicate fenestellid here described. The branches are straight, very regularly parallel, with bifurcation of branches rare; width 0.2 to 0.26 mm., the average being 0.24 mm.; there are 13 to 13.8 branches in 5 mm. Dissepiments regularly about half the width of the branches, very slightly depressed on obverse and reverse sides, and expanded terminally. The fenestrules have a subrectangular outline, the median portion of each side being slightly indented by projecting zooecia. Average dimensions are 0.3 by 0.14 mm.; there are 11 to 12 fenestrules in 5 mm. Zooecial apertures circular, 0.07 to 0.08 mm. in diameter, surrounded by a thin peristome, the orifice in most cases indented by about eight radially directed septa-like spines which give to the apertures a distinctive stelliform appearance. The apertures are disposed along the branches in two alternate ranges, 22 to 24 occurring in each row in 5 mm.; commonly there is one aperture at the end of each dissepiment and one opposite each fenestrule. The branches do not carry a true keel, but bear along the middle a very prominent row of regularly spaced small spines, 0.06 to 0.09 mm. in height, the interval between them being 0.14 to 0.15 mm., 33 to 35 occurring in 5 mm. The obverse and reverse side of branches and dissepiments is distinctly but finely granulose, and in some specimens the granules on the inner side of the branches are longitudinally arranged in lines.

In its micro-measurements *F. condrai* approximates other Pennsylvanian species, *F. limbata* Foerste, *F. mimica* Ulrich, *F. mimica texana* Moore, and *F. cyclofenestrata* Condra. *F. limbata* is distinguished by the different character of its surface, especially the

prominently and somewhat coarsely striated reverse side of the branches, the possession of a definite keel with nodes more closely spaced and less elevated than in our species. *F. mimica* has a very faint keel and small spines spaced 0.12 mm. apart and the fenestrules are markedly indented by projecting zooecia. In *F. mimica texana* the spines are somewhat larger and regularly spaced 0.19 mm. apart. *F. cyclofenestrata* has subcircular fenestrules and lacks spines on the median portions of the branches. None of the compared species appear to exhibit the stelliform zooecial orifices which are so strikingly developed in our specimen.

Horizon and locality.—Near top of South Bend shale member of the Graham formation, one mile west of Graham, Texas.

Fenestella aff. *F. binodata* Condra

We have two nearly perfect specimens which closely resemble *F. binodata* Condra, but differ in measurements sufficiently to make identification on the basis of so few examples doubtful. The branches 0.28 mm. wide and 0.38 mm. thick are straight, 6.5 to 7.5 occurring in 5 mm. The fenestrules, elongate elliptical are strongly indented at the sides by projecting zooecia, 5 to 5.5 occurring in 5 mm. Zooecial apertures subcircular surrounded by a thin peristome which is most prominent on the outer side of the branch, 15.5 to 16.5 occurring in 5 mm. The median one-third of the obverse face of the branches is occupied by a low, bluntly rounded carina which bears two series of small conical spines alternating in position, 31 to 36 in 5 mm., one spine being obliquely posterior to each zooecial aperture; the maximum height of spines is 0.085 mm. The dissepiments, slightly expanded terminally, are distinctly depressed on both obverse and reverse sides. The reverse side of the branches is finely striated.

In typical *F. binodata* there are 6 to 6.5 fenestrules in 5 mm. and 18 to 20 zooecia in 5 mm. According to Condra's figures the zooecia indent the margins of the fenestrules much less markedly than in our specimen.

Horizon and locality.—Near top of South Bend shale member of the Graham formation, one mile west of Graham, Texas.

Fenestella aff. *F. placida* Moore

We have a single, excellently preserved specimen that probably belongs to an undescribed species. It appears more nearly comparable with *F. placida* Moore than other known forms, and in view of lack of material it is here tentatively allied with that species. The branches are straight, nearly smooth, zooecia not indenting the edges of the fenestrules, width 0.4 mm., thickness 0.48 mm.; the spacing indicates the occurrence of seven branches in 5 mm. Dissepiments about half the width of the branches, slightly depressed on the obverse face but not on the reverse side. Fenestrules elongate elliptical in shape, about 1.25 mm. long by 0.35 mm. wide, three and a half occurring in 5 mm. Zooecial apertures subcircular, surrounded by a thin peristome, 0.115 mm. in diameter, 15 to 15.5 zooecia in 5 mm. and 3 to 4 in each series to each fenestrule. The median portion of the obverse face of the branches carries a very narrow crest which bears a row of closely crowded granules and at intervals of about 0.75 to 1.0 mm., a low spine or node. This crest differs from the ordinary keel in that it is not clearly differentiated from the adjacent portion of the branches.

In general appearance the specimen from the South Bend shale corresponds closely to *F. placida* except for its closer crowding of the branches and the average lesser number of zooecia to the fenestrule. In *F. placida* there are regularly about five branches in 5 mm. and five instead of three to four zooecia to each fenestrule.

Horizon and locality.—Near top of South Bend shale member of the Graham formation, one mile west of Graham, Texas.

Polypora elliptica Rogers

The most common representative of the genus *Polypora* in the South Bend section belongs undoubtedly to the somewhat broadly characterized and probably synthetic species designated *P. elliptica*, in which the general form and the dimensions of the zoarium and particularly the regularly disposed nodes on the obverse face are distinctive features. Our specimens show a varying number of branches in 10 mm., ranging from 13 to 18,

the higher number being measured just beyond the points of bifurcation of several branches. The number of fenestrules in 10 mm. is constantly about 10, but in one specimen the number is 14. The zooecia are disposed in two to four alternating ranges, 16 to 18 occurring longitudinally in 5 mm. In several specimens the subcircular zooecial apertures are closed by opercula having a central raised or tumid area and in some cases preserving the central perforation. A feature well shown on our specimens, but not indicated in published descriptions and figures of *P. elliptica* is a narrow well defined ridge upon the lateral margins of branches and dissepiments separating the obverse and reverse faces. The lateral rows of zooecia are somewhat more prominently elevated and the outer margin of the peristomes is produced to form a spine-like projection and in these respects South Bend specimens depart from typical characters.

Approximately one-third of the more delicate specimens of *Polypora* in our collection from the Ranger limestone northwest of Bridgeport exhibit fairly typical characters of *P. elliptica* and though connected by certain intergrading forms with the specimens identified as *P. nodocarinata* var., to a degree sufficient to arouse question concerning the range of specific variation, the specimens here grouped show distinctly the closer spacing of branches and fenestrules and the dominance of three longitudinal zooecial series with intervening double series of nodes that characterize Rogers' species. Our material shows 12 to 15 branches in 10 mm. and 10 to 11 fenestrules in the same space, and the fenestrules are slightly smaller than in *F. nodocarinata* var., measuring 0.27 by 0.35 mm. in most cases and there are 19 to 20 instead of 18 to 19 zooecia in 5 mm.

Horizon and locality.—Near top of South Bend shale member of the Graham formation, one mile west of Graham, Texas; Ranger limestone, twelve miles northwest of Bridgeport, Texas.

Polypora submarginata Meek var.

Almost as numerous as the specimens collectively assigned to *P. nodomarginata* and *P. elliptica* are distinctly coarser forms having about seven branches in 10 mm. and a little less than four

fenestrules in the same space. A majority of the branches show distinctly a more or less prominent central row of spines or nodes, with interspaces largely occupied by the apertures of a median row of zooecia; some of the specimens, several of them fairly large, lack the spines and the absence of evidence of abrasion suggests that these specimens were originally non-spinose. There is almost a complete transition from one type of zoarium to the other and the fact that measurements are identical has led us to the conclusion that they are not properly separable. A portion of the subcarinate, nodose forms exhibit on the reverse side of the branches a more or less distinct row of nodes like those described in *P. triangularis* Rogers.

The branches of our specimens are straight, 0.48 to 1.1 mm. in width averaging 0.7 mm.; the spacing is constantly about 7 branches in 10 mm. The fenestrules are elongate-oval and there is little variation in their length and width which measure respectively 2.0 and 0.6 mm.; the maximum range of the number of fenestrules in 10 mm. is 3.7 to 3.9, the average being 3.8. There are 4 to 7 rows of zooecia on each branch, the average being 5; there are 7 to 9 zooecia to each fenestrule, and 15 to 16 in each row in 5 mm. The apertures are surrounded by a thin apparently complete peristome. The dissepiments are slightly depressed on the obverse side, but even with the branches on the reverse side; they measure 0.27 to 0.4 mm., the average being 0.35 mm.

Scrutiny of the descriptions and figures of present known American Pennsylvanian species of *Polypora* suggest the segregation and comparison of *P. crassa* Ulrich, *P. remota* Condra, *P. distincta* Ulrich, *P. triangularis* Rogers, *P. rudis* Moore, *P. submarginata* Meek, *P. hirsuta* Moore, *P. arata* Moore, *P. valida* Moore, and *P. anastomosa* Mather. To this list might be added, perhaps, the Mississippian species *P. maccoyana* Ulrich and *P. simulatrix* Ulrich all of which exhibit close similarity in the size and spacing of branches and fenestrules. The Pennsylvanian species named may be divided into three groups: (1) the *P. crassa* group consisting of the first five species named, distinguished mainly by their longer fenestrules, averaging 2.5 mm. in length and ranging in some cases to more than 4 mm.; (2) the

P. submarginata group comprising all of the remainder except *P. anastomosa*, with fenestrules not exceeding 2.0 mm. in length; and (3) *P. anastomosa* which is very markedly different from the others in its short, rounded fenestrules and very wide dissepiments. In the first group the number of fenestrules in 10 mm. ranges from 3 to 3.5, and in the second from 4 to 4.5. *P. maccoyana* resembles the first group and *P. simulatrix* the second. The possible genetic significance of this division is suggested by similarities such as in the development of spines within the group. Our specimens show certain characters of both groups 1 and 2, but appear most closely related to *P. submarginata*. The spacing of the fenestrules appears to be a more reliable specific character than the spacing of the branches.

There are noteworthy differences in almost all of the measurements of the species described respectively by Ulrich and Condra as *P. submarginata*, almost the only common character being the prominence of a central row of spines on the obverse side of the branches. Unfortunately Meek gives no definite measurements in describing the type which comes from lower Wabaunsee beds at Nebraska City, Nebraska, and no definite information is obtainable from his figures. Condra does not mention the Nebraska City locality in listing the sources of the material assigned by him to Meek's species, and accordingly it is indicated that none of the Nebraska specimens described by him come from the type locality. Our specimens agree much more closely with the measurements of Ulrich than with those cited by Condra. The reverse side of the branches in *P. submarginata*, according to Meek, is longitudinally striated or smooth, a character in agreement with the larger number of our specimens, but in many of the Texas specimens there is a more or less prominent development of nodes on the reverse of the branches. According to Meek the number of zooecia to the fenestrule in each row ranges from 4 to 6, the average being 5 (his figures show an average of 6); Ulrich's specimens show 5 to 6 zooecia to the fenestrule; Condra indicates there are 6 to 8 zooecia to the fenestrule. Examination of our specimens shows a range of 7 to 9 zooecia to the fenestrule. There are evidently certain differences from typical *P. submar-*

ginata, but the specimens with prominent median row of nodes are evidently more closely related to this species than other described forms. The non-spinose specimens are most closely similar to *P. valida* but have much narrower dissepiments, slightly closer spaced zooecia, and other minor differences.

Horizon and locality.—Ranger limestone, twelve miles northwest of Bridgeport, Texas.

Polypora rudis Moore n. sp.

Plate XXVI, figs. 11, 14

Branches stout, straight or very slightly flexuous, sub-parallel, with few bifurcations; width 0.8 to 0.85 mm. increasing to 1.2 mm. below a bifurcation, thickness about 0.8 mm., gently convex on obverse side, very narrowly rounded on reverse, cross-section of branches subtriangular, there are 6 to 6.5 branches in 10 mm. Fenestrules elongate oval, 0.8 to 0.9 mm. wide by 2.2 to 2.7 mm. long, 3 to 3.5 occurring in 10 mm. Dissepiments about 0.5 mm. wide, widening distally, depressed and more or less distinctly striated on obverse side, very slightly depressed or even with branches on the reverse side. Zooecial apertures in 5 to 6 alternating rows with 14 to 15.5 longitudinally in 5 mm., and about four in 1 mm. diagonally. Apertures surrounded except on posterior side by pustulose peristomes. There are 8 or 9 zooecia in the marginal row to the fenestrule. Obverse side of branches minutely granulose and carrying occasional small spines, reverse side smooth.

Our specimens appear more or less closely related to several Carboniferous species. In measurements and in the shape of the branches *P. rudis* corresponds almost exactly to *P. triangularis* Rogers, but that species is distinguished by a prominent row of nodes on the reverse side of the branches, the obverse side is smooth and the apertures are apparently surrounded by complete thin peristomes. *P. distincta* Ulrich has less rigid branches and more irregular growth, longer and narrower fenestrules and different spacing of the zooecia. *P. crassa* Ulrich has typically somewhat wider branches and larger fenestrules, the zooecial apertures

are more closely spaced and are surrounded by a complete peristome. Nebraska specimens identified with *P. crassa* by Condra are coarser than Ulrich's type. *P. remota* Condra corresponds in spacing of branches and fenestrules, but the dissepiments are more slender and depressed, the branches subcylindrical evenly convex on the reverse side, smooth on the obverse; numerous bifurcation of the branches and more widely spaced zooecia. *P. hirsuta* Moore from the Wayland shale of Texas is distinguished by its slightly smaller fenestrules and the prominently spinose character of the obverse face.

Horizon and locality.—Upper part of South Bend shale member of the Graham formation, one mile west of Graham, Texas.

Polypora nodocarinata Ulrich var.

The preponderant type of *Polypora* in the Ranger fauna northwest of Bridgeport is a rather delicate, spinose form exhibiting variations which make definite assignment to described species difficult. The majority of our specimens exhibit the more or less distinctive surface characters of *P. nodocarinata* Ulrich which carries a prominent row of nodes along the median line of the obverse face of the branches. In the prevalence of four rows of zooecia to the branch, size of fenestrules and other characters our specimens closely correspond to those described by Ulrich. The chief distinguishing feature in the Texas specimens is that the number of branches in all but a few of the examples is about 12 instead of 10 in 10 mm.

Specimens which we include here may be briefly described as follows. Branches straight, about 0.6 mm. wide and 0.45 mm. thick, but in some examples 0.3 mm. thick, in most examples 12 in 10 mm. but ranging from 10 to 12.5. Fenestrules oval, 0.3 to 0.35 mm. wide by 0.67 to 0.9 mm. in length, the average length being 0.75 mm.; there are regularly 8.2 to 9 fenestrules in 10 mm. Zooecia typically in four rows, 18 to 19 in each range in 5 mm. Longitudinal series of small nodes occur between the zooecia, that on the middle of the branch being much the most prominent. Beyond points of bifurcation the branches are narrower and they carry three rows of zooecia in which case the appearance of the

branch closely resembles *P. elliptica* Rogers. Reverse of branches sharply convex in the thicker branched, typical form, more gently rounded in other cases, in some cases showing faint longitudinal striae.

P. nodocarinata is evidently closely related to *P. elliptica* Rogers, *P. bassleri* Condra, and *P. spinulifera* Ulrich. *P. elliptica* is typically a slightly more delicate form with 12 to 16 branches and 10 to 12 fenestrules in 10 mm.; it is distinguished by the prevalence of 3 instead of a larger number of longitudinal rows of zooecia and by 2 series of more or less prominent nodes alternating in position with the zooecial series. However, portions of the zoarium of *P. nodocarinata* may exhibit the characteristic appearance of *P. elliptica* and vice versa. *P. bassleri* has about the same number of branches and fenestrules in unit space as *P. nodocarinata* and appears to be distinguished, if at all, from that species by lack of the strong development of the central row of nodes along the obverse side of the branches. *P. spinulifera* is a slender species having 12 to 13 branches in 10 mm. and 10 fenestrules in 10 mm., small spines being scattered irregularly over the obverse face of the branches. Ulrich figures two specimens (Ill. Geol. Survey, Pl. 61, figs 3, 3a, 4, 4a) from the Pennsylvanian of Illinois and Iowa which are regarded as varieties of this species. The first is possibly assignable to *P. elliptica* and the second corresponds very closely to some specimens which have been similarly identified. Its characters are apparently intermediate between those of *P. elliptica* and *P. bassleri*. This group of species is rather abundantly represented in the Pennsylvanian and the evident interrelation of forms requires careful examination with reference to stratigraphic distribution.

Horizon and locality.—Ranger limestone, twelve miles northwest of Bridgeport, Texas.

Pinnatopora flexuosa Moore n. sp.

Plate XXVI, figs. 18, 19

Zoarium pinnate, the midrib about 0.5 mm. in width, more or less strongly flexuous, the pinnae, 0.3 to 0.35 mm. wide, being given

off alternately on each side of the point of convex curvature of the midrib. Reverse side evenly rounded and bearing strong longitudinal striae. Obverse gently rounded and rising to a rather prominent sharp crested keel, the surface marked by fine longitudinal or somewhat irregular granulated striae. Four pinnae and interspaces occur on one side of the branch in 2.5 mm. Zooecial apertures elliptical surrounded by peristomes, 0.15 mm. long by 0.115 mm. wide; they are disposed in two alternating ranges along the midrib and pinnae, 13.5 to 14.5 occurring in 5 mm.

P. flexuosa is readily separated from associated specimens of *P. trilineata texana* Moore which in most cases has a straight midrib, a low and definitely trilineate keel, and more closely spaced zooecia. *P. flexuosa* is rather abundant in the South Bend shale west of Graham.

Horizon and locality.—Near top of South Bend shale member of the Graham formation, one mile west of Graham, Texas.

Pinnatopora paucanoda Moore n. sp.

Plate XXVI, figs. 15, 16

Zoarium pinnate, midribs straight 0.45 to 0.49 mm. wide, the reverse side evenly rounded and bearing strong longitudinal striae, the obverse with minute granules and longitudinal striae, the granules more or less distinctly arranged in longitudinal rows. The median portion of the obverse face bears a low but distinct keel which is more or less distinctly trilineate and bears at intervals ranging from 0.8 to 1.2 mm., and averaging 1.0 mm., a small but well defined node. The pinnae, 0.3 mm. wide, are rather regularly spaced on the two sides of the midrib, four pinnae and interspaces occupying 3.7 mm. Zooecial apertures elliptical surrounded by a peristome, seven occurring in 5 mm.

P. paucanoda most closely resembles *P. trilineata texana* Moore, from which it is differentiated by slight differences in measurements and by the presence of nodes on the keel.

Horizon and locality.—Near top of South Bend shale member of the Graham formation, one mile west of Graham, Texas.

Streblotrypa plummeri Moore n. sp.

Plate XXVI, fig. 17

Zoarium a slender cylindrical stem, branching at infrequent intervals dichotomously at an angle of about 45 degrees from the axis of the stem, and laterally at approximately right angles to the stem; diameter 0.75 to 1.0 mm. Apertures cylindrical, about 0.2 mm. in length by 0.15 mm. in width, arranged in alternating longitudinal series, 11 to 12 occurring in 5 mm. and diagonally 4 in 1 mm. Between the longitudinal series are poorly defined, slightly sinuous ridges, and in the depressions between these low ridges and below the aperture are 10 to 22 small pits arranged in 2 to 5 rows and with a narrow row commonly extending on each side of the aperture nearly to its anterior margin. Apertures surrounded by a thin peristome.

This species most closely resembles *S. prisca* with which it is associated in the South Bend fauna, but specimens are readily differentiated by the smaller size of the apertures, the much larger number and different arrangement of the pits, and the sharply defined character of the longitudinal series.

Horizon and locality.—Near top of South Bend shale member of the Graham formation, one mile west of Graham, Texas.

PLATE XXVI

Figs. 1, 2. *Fenestella nodulosa* var. *minor* Moore n. var., 1, obverse view of a cotype, × 10; 2, reverse view of same, × 10.

Figs. 3, 4. *Fenestella nodulosa* Moore n. sp., 3, obverse view of a cotype, × 10; 4, reverse view of same, × 10.

Figs. 5, 6. *Fenestella geminanoda* Moore n. sp., 5, obverse view of the holotype, × 10; 6, reverse view of same, × 10.

Figs. 7, 8. *Fenestella minuta* Moore n. sp., 7, obverse view of a cotype, × 10; 8, reverse view of same, × 10.

Figs. 9, 10. *Fenestella bispinulata* Moore n. sp., 9, obverse view of a cotype, × 10; 10, reverse view of same, × 10.

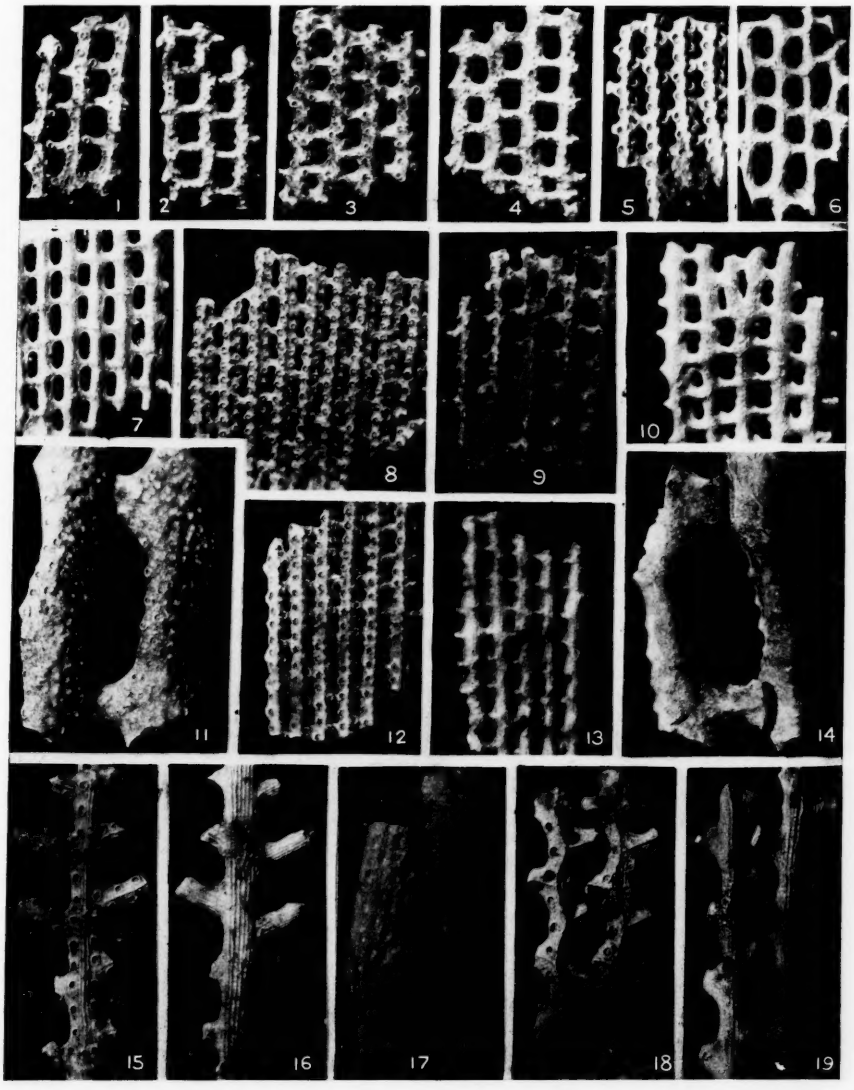
Figs. 11, 14. *Polypora rudis* Moore n. sp., 11, obverse view of a cotype, × 10; 14, reverse view of same, × 10.

Figs. 12, 13. *Fenestella condrai* Moore n. sp., 12, obverse view of a cotype, × 10; 13, reverse view of same, × 10.

Figs. 15, 16. *Pinnatopora paucanoda* Moore n. sp., 15, obverse view of a cotype, × 10; 16, reverse view of same, × 10.

Fig. 17. *Streblotrypa plummeri* Moore n. sp., views of two cotypes, × 10.

Figs. 18, 19. *Pinnatopora flexuosa* Moore n. sp., 18, obverse view of two cotypes, × 10; 19, reverse view of same, × 10.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